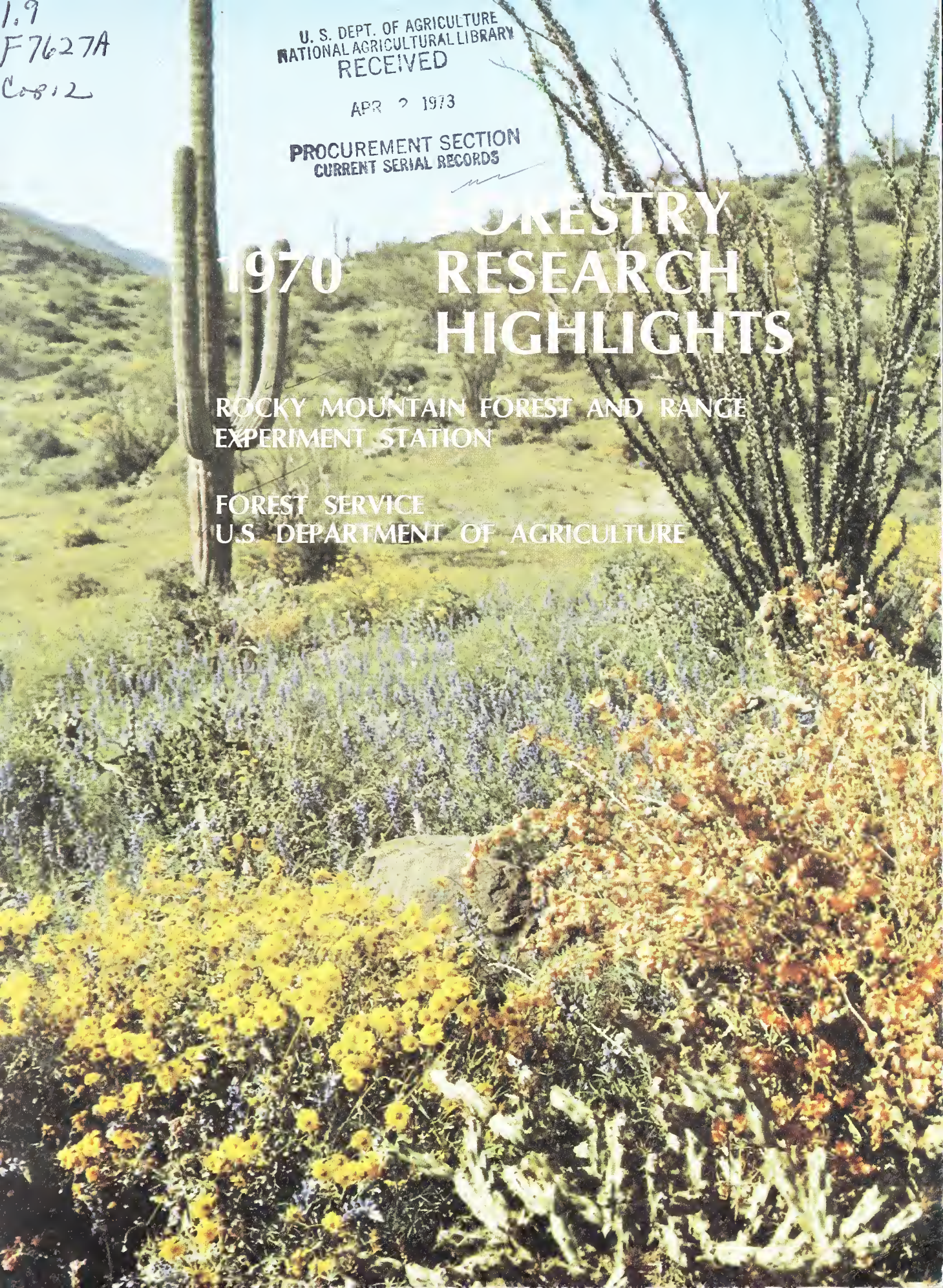

FORESTRY RESEARCH HIGHLIGHTS 1970

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

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Growth Chamber Quickly Produces Ponderosa Pine Seedlings

New high-light-intensity growth chambers are being used by scientists at Bottineau, North Dakota, to find optimum growing conditions for the production of conifers in a greenhouse. The rapid production of tree stock for shelterbelt planting is a primary goal.

A recently completed experiment shows that ponderosa pine grows best when the daytime temperature is 19° to 25° C. with an atmosphere containing 1,200 p.p.m. carbon dioxide and a 16-hour day of light intensities approaching sunlight. Growth decreases sharply at higher temperatures.

Night temperatures are less critical and may vary from 13° to 25° C. with little effect on growth.

A greenhouse for growing ponderosa pine, therefore, must be capable of keeping maximum temperatures down to 25° C., but fuel can be saved by letting the temperature drop at night.

Growth-chamber-grown ponderosa pine at 4.5 months of age. Maximum growth was obtained with a constant day and night temperature of 25° C. Trees up to 20 centimeters in shoot height, 11 millimeters in caliper, and 84 grams fresh weight were produced. Background lines are 10 centimeters apart.

Growth Retardants Effective for Deciduous Nursery Stock

Nurserymen often must plow under unsold trees because they are too large. Controlled subdued growth would permit holding the unsold crop for the following year. A 2-percent spray of Alar in June successfully retarded the growth of villosa lilac, green ash, cotoneaster, and Siberian elm in North Dakota. Slo-gro was more effective than Alar on Siberian elm. June treatments were more successful than July treatments. Research is continuing to determine the duration of the retardant effect.

Two-year-old Siberian elm in a North Dakota nursery. The center row showed a definite reduction in growth 4 months after a June spraying of growth retardant.

Wood Density Unchanged by Rapid Growth of Ponderosa Pine in the Black Hills

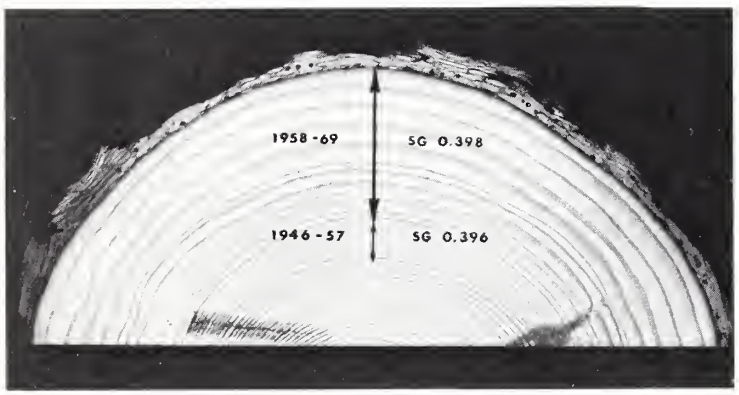
Until recently, most of the timber harvested from the ponderosa pine forests of the Black Hills came from trees which grew slowly in crowded stands. Research has shown that ponderosa pine will grow very rapidly in the Black Hills when given abundant space. Wood processors and users have questioned whether the fast-grown wood has the same technical properties as the slow-grown wood to which they have become accustomed.

As a first step toward answering that question, we conducted a small study to determine whether a drastic change in tree growth rates was accompanied by a change in wood density. That important property, measured in terms of specific gravity, is a reliable indicator of strength, hardness, and other wood usability characteristics.

Density data came from six pole-sized ponderosa pines which were cut in a demonstration of intensive thinning. The trees had grown very slowly for several decades in a typical overstocked stand. They then grew rapidly for 12 years in response to two thinnings made 7 years apart. After the trees were felled in a third thinning, paired samples of fast- and slow-grown wood were removed at regular intervals along the full length of each stem. Specific gravity was determined for each sample.

Comparison of specific gravity values showed that wood formed during the 12 years after the first thinning had virtually the same density as did wood formed during the 12 years preceding treatment. The average specific gravity of all slow-grown wood samples was 0.396 $\pm$ 0.004, while that for wood grown four times as fast, after thinning, was 0.398 $\pm$ 0.005. As a check on the uniformity of growing conditions during the two periods, matched sets of samples were taken from six trees in an unthinned portion of the same stand. Specific gravity values for these samples showed no significant difference in wood density from one period to the next.

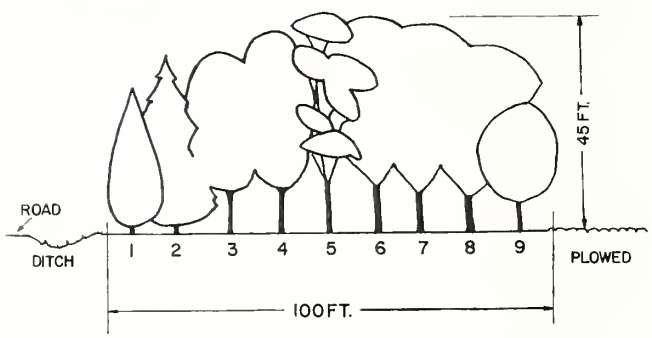
The data revealed considerable variation in specific gravity, both between and within trees. The three trees with the densest wood before thinning also formed the densest wood after thinning. All trees exhibited a fairly distinct trend of decreasing specific gravity with increasing height above the stump, up to about the middle of the live crown.

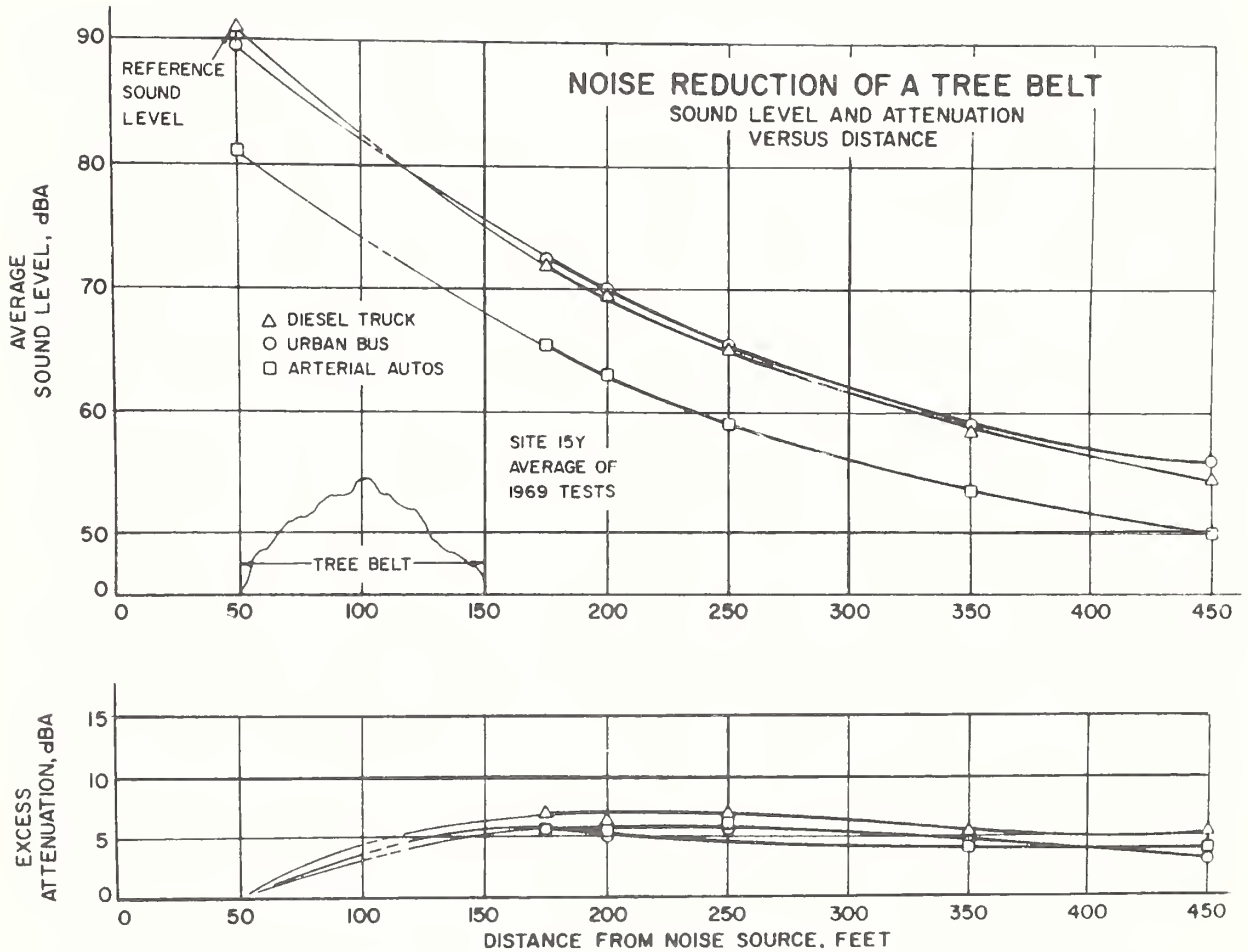


A fourfold increase in the growth rate of ponderosa pine in the Black Hills, caused by thinning, did not significantly change wood specific gravity.

Tall, wide tree belts are particularly effective in reducing noise. Belt 15Y, one of the belts studied, is illustrated here. It contains the following rows of tree species:

1. *Eastern redcedar*
2. *Ponderosa pine*
3. *Green ash*
4. *Hackberry*
5. *Honeylocust*
6. *Siberian elm*
7. *Siberian elm*
8. *American elm*
9. *Red mulberry*





The above graphs illustrate the noise reduction characteristics of Belt 15Y. Each of the three noises (diesel truck, urban bus, arterial autos) used in the experiments is represented by an individual curve, and the sound levels at any distance from the noise source may be read in dBA units from the upper graph. The lower graph presents excess attenuation curves for each noise source that show the amount of sound reduction (attenuation) due to the trees alone. This reduction is in excess of natural attenuation due to distance, atmosphere, ground absorption, and other effects. The dBA unit is a "weighted" measure of sound pressure level which provides a relatively high correlation with subjective loudness estimates of certain noises.

Trees Are Effective Noise Barriers

Noise, or unwanted sound, can be reduced by as much as 10 decibels (50 percent) by properly located barriers of trees and shrubs. Combinations of tree-shrub barriers with grass approaches can lower sound levels approximately 15 decibels (about 65 percent). These findings came from a study conducted by the University of Nebraska College of Engineering. The work was funded by the Forest Service, U. S. Department of Agriculture, and it was technically aided by personnel of our Lincoln field office.

Traffic noises from trucks, passenger cars, and buses were recorded and played back at their recorded sound level through several types of tree belts in southeastern Nebraska. Sound levels were measured at varying distances behind the belts. Comparisons were made with measurements taken under similar conditions at nearby locations where no trees or shrubs were present. Results indicate that:

1. Tree species do not differ greatly in their ability to reduce traffic noise levels, but evergreen varieties are best when year-round noise screening is desired.

2. Significant sound reductions can be achieved from narrow, dense tree belts; but tall, wide belts, in general, are more effective because they provide a greater surface area for diffusion and absorption of sound.

3. Distances of 75 feet or more should be available for planting between the noise sources and the area to be protected.

4. Dense barriers formed by planting several rows of trees closely together are more effective.

5. Noise screens should be placed as closely as possible to noise sources, consistent with safety.

Engelmann Spruce Seed Production Is Irregular

No regular pattern of Engelmann spruce seed production was evident after 6 years of observation on five Colorado study areas.

Good crops of 100,000 or more seeds per acre were produced only once in 4 or 5 years on three areas; elsewhere seed crops were good in 2 of 6 years. Seedfall into clearcut openings decreased rapidly beyond about 100 feet from the standing timber, but a considerable number of sound seed was dispersed across openings in years of good seed production.

Seedling survival was poor on all areas, indicating that the limiting factors to seedling establishment are related more to adverse environmental conditions than to seed supply.

Environmental Factors Greatly Influence Engelmann Spruce Establishment and Survival

Three studies concerning the environmental requirements for the successful establishment and survival of Engelmann spruce are underway in Colorado.

1. The influence of summer precipitation patterns on Engelmann spruce establishment. Germination and initial survival of potted spruce grown in a greenhouse were compared under watering treatments selected to represent precipitation patterns most likely to occur in the field. The following relationships can be drawn from these studies:

When monthly rainfall during the summer averages 1 inch or less, more seedlings emerge with frequent showers than with one or two larger storms of longer duration. When monthly rainfall during the summer averages 1 inch or more, total germination is completed in a relatively short time with frequent showers, whereas seedlings emerge throughout the growing season if precipitation is irregular.

At least 1 inch of favorably distributed precipitation is needed monthly before seedlings survive in significant numbers. With this precipitation pattern, however, seedling survival is not likely to be greatly increased with more than 1.5 inches of monthly rainfall. On the other hand, few seedlings will survive with less than 2.0 inches of rainfall monthly when precipitation occurs only infrequently.

2. The influence of drought on Engelmann spruce survival. Potted spruce seedlings grown in a greenhouse were able to withstand apparently high water stress. Seedlings lived for as long as 49 days without additional water following initial soil saturation, but they died when needle water deficit reached approximately 58 percent. Seedlings with needle deficits below the lethal point recovered when rewatered, even though 1-year and older needles were shed in increasing numbers as water deficits exceeded 53 percent. Water stresses greater than 42 percent which were not great enough to cause defoliation stimulated the growth of new shoots from dormant buds. The faded green color retained by spruce needles up to the highest deficit recorded (78 percent) indicated that extreme water deficits were not the cause of chlorosis previously observed in field-planted seedlings.

Water deficits of spruce seedlings planted in the field were well below the lethal deficit of 58 percent, indicating that drought is probably not the cause of heavy mortality in spruce plantations. In addition, it does not appear likely that environmental conditions where spruce grows are conducive to excessive transpiration; water deficits measured at midday were not significantly different from those at sunrise when seedling turgidity is at maximum. Furthermore, water deficits of seedlings measured at 30-day intervals during the growing season were nearly the same whether open grown or partially shaded.

3. The influence of drought on Engelmann spruce photosynthesis and respiration. Potted spruce seedlings maintained maximum rates of photosynthesis and respiration for approximately 25 days after the soil was saturated. Thereafter, small changes in needle water deficits appreciably inhibited these life processes. At water deficits of 10 percent or less, apparent photosynthesis was generally at the maximum observed rate while dark respiration ranged from 55 to 100 percent of maximum. Minimum rates of both processes were reached at a water deficit of 20 percent. At deficits greater than 20 percent, photosynthesis was zero and respiration was less than 20 percent of maximum.

Mixed Conifer Seedlings Grow Much Faster in Clearings Than in Small Openings

Naturally established seedlings in the mixed conifer forests of the Southwest have earned a reputation for slow growth. We collected field data to determine how slowly they grow.

At an elevation of 9,100 feet in Arizona's White Mountains, seedlings grow very slowly in small openings such as those formed by the death or removal of a single large tree. Healthy, undamaged Engelmann spruce seedlings averaged slightly more than 5 inches in height after six growing seasons. Six-year-old corkbark fir were about the same height, while white fir were slightly shorter at the same age. Douglas-fir seedlings tended to be deteriorating at age 5, but those that were healthy were about as tall as the other species.

In contrast, natural seedlings in a nearby clearing grew much faster. The height of 6-year-old ponderosa pine, Douglas-fir, and Engelmann spruce averaged 26, 21, and 14 inches, respectively. The fastest growing Douglas-fir was 42 inches tall at age 6, having grown 24.5 inches during its sixth summer.

At 10,600 feet in the same mountain range, Engelmann spruce that had seeded into a burned area averaged 13 inches in height at age 6.

Moisture Not a Limiting Factor for Survival of Mixed Conifer Seedlings

Internal moisture stress was measured in a large number of Douglas-fir, ponderosa pine, Engelmann spruce, and corkbark fir seedlings in mixed conifer forests and forest openings of eastern Arizona. Even during the last days of the spring-early summer dry season, midday moisture stress maximums were almost always less than 250 p.s.i., the approximate wilting point. Nocturnal recovery to about 100 p.s.i. was complete in early evening. Tree size did not affect moisture stress levels in trees taller than about 5 inches.

These results are compatible with the generally low or moderate soil moisture stress found at depths below 4 inches in the same locale. Moisture stress is not an important killer of mixed conifer regeneration in eastern Arizona, once the seedlings are 3 inches tall. Natural seedlings which are 3 inches tall are usually 3 to 6 years old, and they have roots that penetrate from 4 to 10 inches. Drought should seldom kill or seriously impair the growth of good planting stock that has been properly planted.

A

B

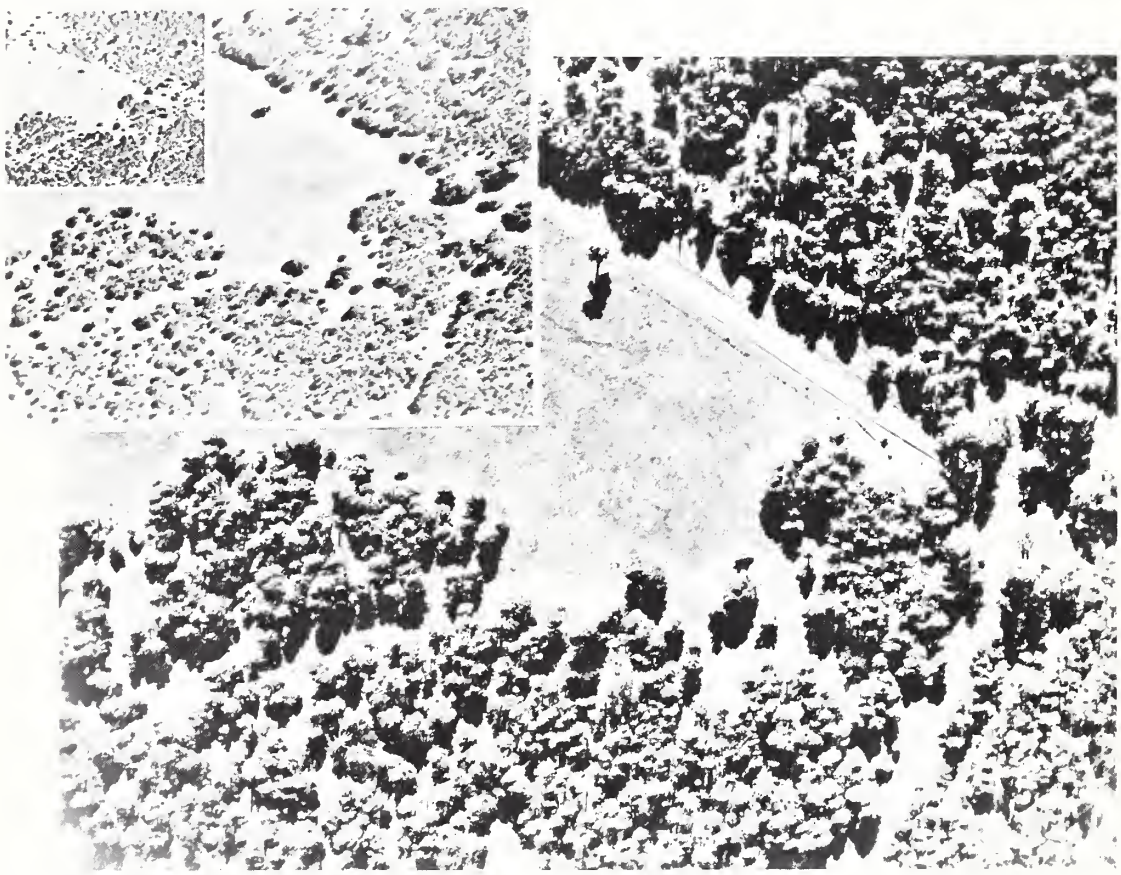
Studies were conducted to determine the height growth of mixed conifers in the White Mountains of Arizona. A: A typical 6-year-old ponderosa pine that was naturally established in a clearing. B: An exceptional 7-year-old Douglas-fir that was also naturally established in a clearing.

Aerial Photo and Ground Measurements of Ponderosa Pine Stands Compared

Small-scale aerial photographs are useful tools for resource managers who need information about the forest cover and topography of large areas. Less is known, however, about the capabilities of large-scale photos as sources of detailed information on timber production and topography. Ponderosa pine cubic-foot volume and basal area, as well as aspect and slope steepness, were estimated on ground plots on the Beaver Creek Watershed and on corresponding panchromatic contact prints having photo scales of 1:3,000, 1:6,000, and 1:15,840. Ground estimates were made by averaging data from five point-samples located within 1-acre circles. Centered on these ground plots were 1/5- and 1-acre photo plots.

All ground estimates of cubic-foot volume and basal area were significantly correlated with photo estimates. Estimates made on 1/5-acre photo plots were not significantly different from those made on 1-acre plots, and photo scale had no apparent effect. Thus, it can be concluded that all of the scales and plot sizes tested can be used to estimate timber volume and basal area. However, the estimates were most easily made from photos at the 1:6,000 scale. Photos at the 1:3,000 scale were more difficult to use because of the displacement of treetops due to parallax. Photos at the 1:15,840 scale lacked sufficient resolution and visible detail to be used easily.

We also found that suitable slope and aspect data are obtainable from photos at any one of the three scales tested.



Three aerial views of a portion of the Beaver Creek Watershed in Arizona illustrate (from left to right) the relative detail obtained at photo scales of 1:15,840, 1:6,000, and 1:3,000.

Forest Service Herbarium Moves to Colorado

The Forest Service Herbarium was moved in 1970 from the Washington, D. C. headquarters of the U.S. Department of Agriculture to the Rocky Mountain Forest and Range Experiment Station on the campus of Colorado State University in Fort Collins.

The herbarium, containing more than 150,000 specimens, is one of the largest collections of range plants in the United States. Most of the specimens are annotated with ecologic notes and data concerning forage values for livestock and wildlife.

The plant collection includes trees as well as grasses, forbs, and shrubs. It is particularly rich in material from the western national forests, including the less accessible mountainous regions, and it also contains specimens from other regions of the United States, including Puerto Rico and Alaska.

Cattle Seek Forbs in Their Diet

Herbicides applied to subalpine test ranges in the Big Horn Mountains of Wyoming reduced forb composition from 79 to 9 percent. Yet the forb composition of rumen samples from yearling steers grazing treated range was 33 percent while that for animals grazing untreated range was only slightly higher at 42 percent. Most forbs could not be identified in the rumen samples, but of those that could be identified, common dandelion, yarrow, silvery lupine, and Richardson geranium were the most frequent in animals grazing both treated and untreated ranges. Diet quality, as measured by the volatile fatty acid (VFA) levels in the rumens, was similar despite drastic changes in plant cover.

This study is being conducted in cooperation with scientists at the University of Wyoming.

Effects of Drought Override Improvement of Salt-Desert Shrub Ranges

Plant cover on a salt-desert shrub winter range west of Grand Junction, Colorado became more sparse over a 10-year period, regardless of whether the area was grazed by livestock. Drought was evidently responsible. Annual precipitation was below normal during 8 of the 10 years. Galleta and shadscale saltbush on sandy soil were especially vulnerable to drought. Broom snakeweed, commonly regarded as an indicator of overgrazing, decreased markedly on both ungrazed and grazed range. Although several plant species, including Gardner saltbush and Greenes rabbitbrush, did respond to grazing, current findings leave little doubt that weather must be considered when evaluating responses of salt-desert vegetation to grazing management.

Moderate Grazing Maintains Idaho Fescue on Thurber Fescue Range

Idaho fescue remained relatively productive on Black Mesa in western Colorado where it was about 50 percent grazed. Under light grazing it became less productive over a 13-year period. Its contribution to standing herbage on ungrazed range declined from 28 to 16 percent, a reduction of 170 pounds per acre. Decreases in Idaho fescue were offset in part by increases in Thurber fescue. The latter is considered climax on many mountain grasslands in the central Rockies. The intensity of cattle grazing, however, may determine the relative prominence of either species.

Thurber fescue on a lightly stocked cattle range in western Colorado. If overgrazed, this tall bunchgrass may be replaced by Idaho fescue.

Trained Range Personnel Rate Plant Cover Similarly

Plant cover measurements are used by national forest administrators to detect changes caused by grazing, fire, and other factors. Tests conducted on both high and low production sites on 17 national forests or experimental areas in the West indicate that trained range personnel rate small plots or "microplots" similarly in respect to the area occupied by aerial and basal plant cover. Although differences were noted on individual plant species and on some sites, the observers were very consistent in their ratings on larger samples. The plots used in the tests ranged in size from 1/8 square inch to 8 square inches. Equal area rectangles and circles were used, and all are well suited for rating plant cover.

Three-Pasture Grazing System Insures Proper Use of Cool- and Warm-Season Grasses

A three-pasture rest-rotation grazing system effectively insures the proper use of cool- and warm-season grasses on ponderosa pine ranges in Arizona. One pasture is grazed in spring and early summer; the second is grazed in late summer and fall, and the third pasture is not grazed during the entire season. Our tests of this system found that plant and cattle productivity were maintained, and that utilization was more uniform on Arizona fescue, which grows primarily on winter-spring moisture, and on mountain muhly and other warm-season grasses, which are dependent on summer rainfall.

Cattle Gains Estimated from Digestible Forage Consumption

Beef gains per acre were related to *in vitro* digestible forage consumption per acre on ponderosa pine ranges in Arizona. While forages may differ in nutritive value from year to year and from range to range, forages from different ranges can be compared by digestibility measurements. The relationship is useful for predicting beef production where forage can be measured but beef gains cannot. The equation used to determine daily intake requirements for the maintenance and gain of range cattle is similar to that used to make the same determinations for feedlot cattle:

$$DDM = 0.033w^{3/4} (1 + 0.479g)$$

where DDM = mean daily *in vitro* digestible dry matter intake in pounds
w = mean body weight in pounds
g = mean daily weight gain in pounds

Differences in ground cover measurements were small among plots of various shapes and sizes and among observers.

Aerial Photos Used to Identify and Quantify Range Vegetation

Keys have been developed to identify six herbaceous species and three soil surface features on large-scale color and color infrared aerial photographs. The herbaceous species which can be identified at a scale of 1:600 are blue grama, mountain muhly, Arizona fescue, pussytoes, trailing fleabane, and fringed sagebrush. Rodent mounds, rodent holes, and bare soil are the identifiable surface features. June photographs resulted in the highest percent correct identification (64 percent) for both plant species and surface features. Color infrared film provided the highest correct identification of herbaceous species: 74 percent for grasses and 61 percent for forbs. Regular color film provided the highest correct identification (86 percent) of surface features.

Color infrared aerial photos at a scale of 1:80,000 had limited value for identification of specific plant communities. Differences between oak and oak-juniper communities near Roswell, New Mexico could not be discriminated with this photoscale. The oak and oak-juniper communities could, however, be separated from herbaceous communities on photos at 1:80,000. Color infrared aerial photos at a scale of 1:20,000 provided the necessary resolution to separate all three communities. Photos at 1:2,400 provided the detail necessary for determining the identity and density of individual shrubs spaced more than 3 feet apart.

Higher Animal Gains Associated with Light Grazing and High Forage Production

Daily gains of yearling cattle were inversely related to percent utilization on three ponderosa pine ranges in Arizona. Highest individual animal gains were obtained from light grazing on pastures producing the most forage. Range where trees had been clearcut produced 842 to 1,689 pounds of forage per acre; range where pine was thinned produced 296 to 684 pounds per acre; and range with a natural, untreated pine overstory produced 51 to 63 pounds per acre.

The following regression equations show the relationship for the three ranges:

Clearcut: $Y = 1.64 - 0.015X$
Thinned: $Y = 1.44 - 0.015X$
Untreated: $Y = 0.96 - 0.016X$

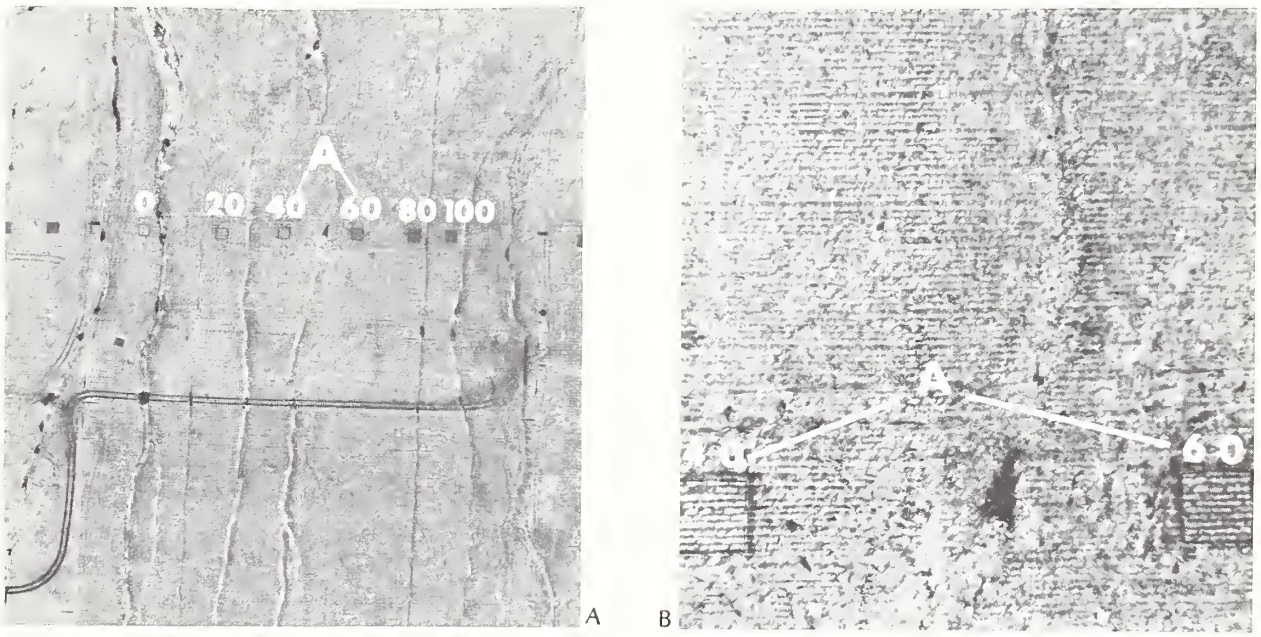
where Y = daily weight gain per animal
X = percent utilization

Range Utilization Levels Distinguishable from Color Infrared Aerial Photos

Analysis of aerial or space photography includes a quantification of herbage in specified plant communities. Six levels of herbage removal were mechanically created within a stand of big bluegrass in Colorado. The stand was photographed at two scales, 1:563 and 1:3,855, during the peak of the growing season. The photos were scanned with a microdensitometer, and the data were analyzed to compare differences among treatments for each photoscale. Significant differences ($P = 0.05$) were detected between the 0, 20, and 40 percent and the 80 and 100 percent herbage removal treatments. In all but one case, the unclipped (0) treatment was significantly different ($P = 0.05$) than all others, and the 80 percent treatment was significantly different ($P = 0.05$) from the 100 percent treatment. Visual examination and interpretation of the photos could also determine differences among the treatments.

Southwestern Plants Not Randomly Distributed

Most of the dominant grass-shrub species in southern Arizona are highly "contagious" or clumped. An understanding of the vegetational pattern is important in the study of plant-animal ecosystems. Estimates derived from point-centered-quarter-distance measures deviated greatly from expected values of random plant dispersions. Mode of reproduction is probably the primary factor in establishing the clumped pattern of the individual species.



Aerial photographs of the same 3- by 3-meter plots in a stand of big bluegrass in Colorado. Black-and-white prints for publication here were made from color infrared transparencies at scales of 1:3,855 (A) and 1:563 (B). Numbers indicate percent of herbage removed from the plots.

A

B

C

Lehman lovegrass stand with scattered clumps of shrub live oak. A: January 1969 before burn. B: February 11, 1969, immediately after burn. C: October 20, 1970.

Herbage Production in Utah Juniper Type Related to Precipitation and Tree Overstory

Removal of the Utah juniper overstory from experimental areas of the Beaver Creek Watershed increased yields of understory vegetation more than fourfold.

The yields of understory vegetation with an undisturbed juniper overstory averaged 223 pounds per acre. These yields were inversely correlated with the amount of tree crown cover. Yields of understory vegetation with the juniper overstory removed averaged 981 pounds per acre.

Under an undisturbed overstory, different plant types responded differently to precipitation periods. Yields of annual grasses were most related to June-August precipitation, yields of perennial grasses to January-August precipitation, and shrub yields to January-May precipitation. Forbs and half-shrubs under a tree overstory showed little response to precipitation differences.

Midwinter Grass Fire Topkills Shrubs with Little Injury to Lehmann Lovegrass

Burning a moderate stand of Lehmann lovegrass in mid-February resulted in 90 percent topkill of 6-year-old shrub live oak sprouts scattered throughout the grass stand. Less than 5 percent of the mature lovegrass plants were killed. The fire followed by 4 days an 0.88-inch rain; hence, soils and grass leaf bases were moist. The dry grass tops burned readily in a light breeze.

One year later, lovegrass density had increased about 20 percent on the burned area, while it had decreased 5 percent on the check (unburned) area. Herbage production declined 30 percent on the check area and 20 percent on the burned area. If further research verifies these results, controlled fire can be used to help maintain a grass-dominated grass-shrub community with less use of herbicides.

A

B

A shrub live oak as it appeared in 1920 (A) and in 1967 (B). Although there was deadwood in the crown in 1967, vigorous sprouts were growing from the base of the plant.

Chaparral Longevity Variable

The longevity of chaparral species varies as shown by repeat photographs of plants tagged in 1920 on the Sierra Ancha Experimental Forest, Arizona. Shrub live oak appears to be the most long-lived species; seven of eight plants were still alive and vigorous in 1967. All tags were found on dead stems, which suggests there has been replacement of the overstory by sprouts during the period.

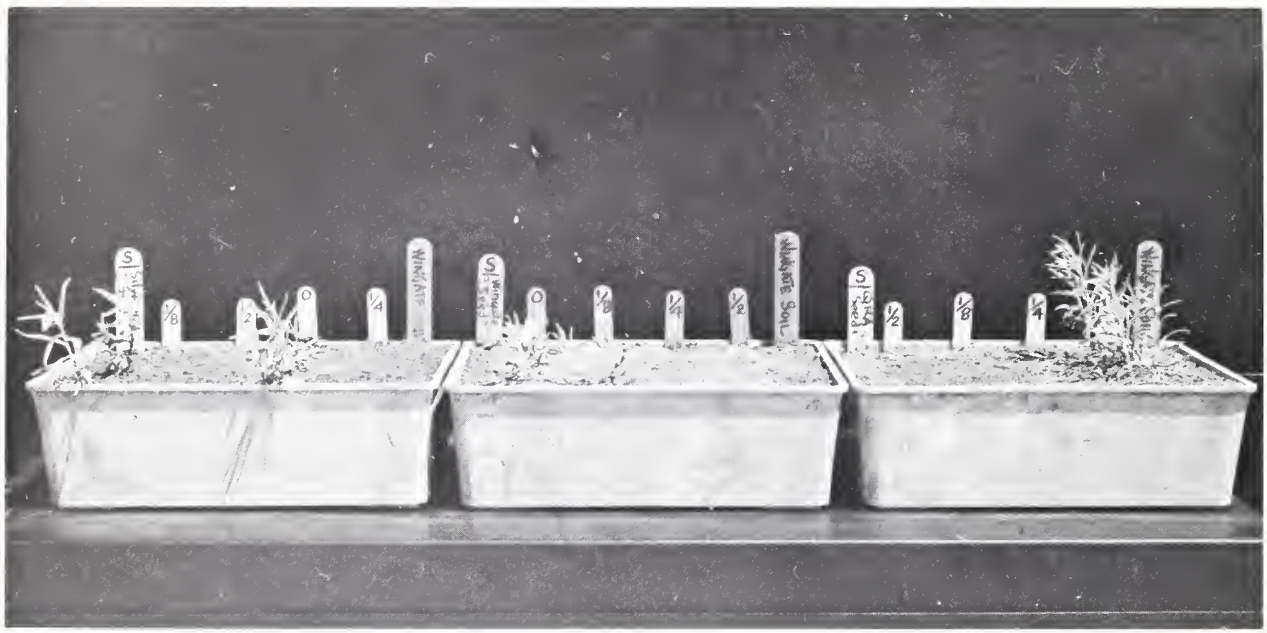
Skunkbush, manzanita, and wait-a-bit persisted for the entire period. Desert ceanothus specimens were presumed to have died within 20 years. The longevity of sacahuista is uncertain since none of the original plants was found in 1967, and photographs were not taken after 1927.

Semidesert Grasses Increase with Spring Rainfall

Precipitation overrides most other influences that affect grass cover on the Santa Rita Experimental Range in Arizona. Mesquite control, for example, increased perennial grass cover, but it did not eliminate the ups and downs associated with year-to-year precipitation differences. From 1957 to 1966, the greatest increases were made in years having better-than-average spring rainfall. The correlation coefficient between grass cover and spring rainfall was 0.76. High spring rainfall, followed by a favorable summer rainy season, produces even greater increases in grass cover.

Plant Winterfat Seeds on or Near Surface

Winterfat seeds used in livestock range and wildlife habitat improvement projects should be planted on or near the surface. Fruits and seeds from three sites in New Mexico were planted at four depths in soils from those sites. Seedling emergence and survival were highest from surface planting and decreased with depth. No seedlings emerged from the ½-inch depth. Threshed seeds showed advantages over whole fruits, especially for surface planting. Soil moisture was held between field capacity and saturation during the tests. Results might have been different in drier soils.



Emergence and survival of winterfat seedlings were best from seeds planted on the surface.

Summer Deferment May Not Improve Semidesert Range

Semidesert ranges deferred from June through October and grazed from November through April did not fare as well as those that were grazed during the summer or those that were grazed yearlong. Tests were conducted on the Santa Rita Experimental Range near Tucson, Arizona. Grazing from November through April is believed to be detrimental because it imposes a greater load on perennial grasses during the spring growth period when new culms are being initiated. Poor performance of perennial grasses was accompanied by greater increases in shrub cover, especially burroweed. Shrub increases were largest where grass increases were smallest, possibly because grazing and regrazing in early spring weakened the perennial grasses, thereby clearing the way for greater expansion of the shrubs.

Pinyon-Juniper Removal on Springerville Soils May Produce Little Forage

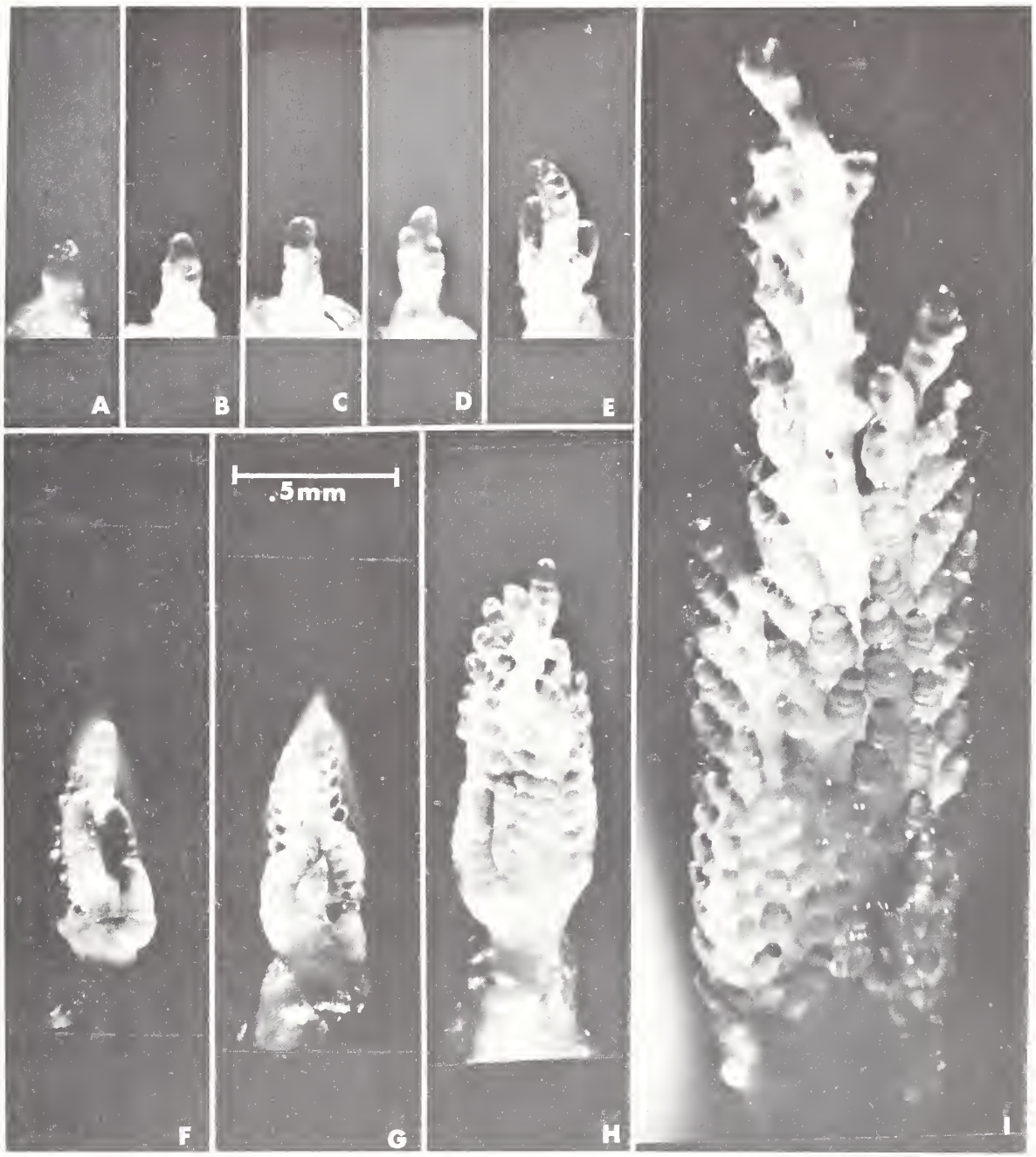
There are approximately 14 million acres of pinyon-juniper woodlands in Arizona. Private individuals and land management agencies have attempted to improve the range forage supply by removing pinyon-juniper from over 1 million acres. Our studies on Springerville soils of the Beaver Creek Watershed in central Arizona indicate that such treatment, followed by seeding of forage species, may not greatly improve forage yields.

Total herbage increased substantially after removal of the pinyon-juniper, but the portion of forage plants in this increase was highly variable. Forage yields increased moderately on those sites which had remnants of perennial native grasses or where there had been some success in establishing seeded grasses.

Arizona Cottontop Seed Heads Develop Rapidly

Arizona cottontop is one of the most valuable perennial grasses on semidesert grass-shrub ranges. On the Santa Rita Experimental Range in Arizona, seed heads appear about 3 weeks after summer growth begins in July, and new seed heads are initiated as long as soil moisture is available, which may be into October.

Stages in the morphological development of shoot apices of Arizona cottontop are illustrated on the facing page. The developing seed head of Arizona cottontop will pass through the stages shown in about 24 hours.



Stages in the morphological development of shoot apices of Arizona cottontop. A: Vegetative growing point with cowl-like hood pushing up from far side. B, C: Vegetative growing points elongating preparatory to becoming reproductive. D: Raceme initials forming on reproductive growing point. E: Spikelet initials forming on upper part of main axis, branch racemes smooth. F, G: Spikelet initials showing on all branch racemes. H: Glume primordia on upper protuberances. I: Advanced stage of flower development with floret protuberances in various stages of development.

Fourwing Saltbush Can Be Field Planted Successfully

Several methods of planting fourwing saltbush were tested on alluvial flood plains behind newly constructed flood detention structures on the Rio Puerco in New Mexico, where the Bureau of Land Management, U.S. Department of the Interior, is using fourwing saltbush to trap sediment and provide food and cover for quail.

Transplants, 4 to 6 weeks old, were field planted in July. All sites were treated with straw mulch and animal repellent immediately after the seedlings were planted.

Preliminary conclusions indicate that fourwing saltbush can be planted and grown most successfully by:

1. Growing transplants from native seed (seed collected from plants growing near the area to be replanted). Ecologically, this is an accelerated method of getting native plants to reinvade devastated areas.
2. Field planting 4- to 6-week-old transplants that have been grown by certain techniques.
3. Field planting with plant bands at ground level, not in depressions.
4. Field planting in low areas that will receive some flood waters, but where water will not submerge the new transplants for longer than 30 hours.
5. Field planting soon after the area has been flooded to insure some available soil moisture, since transplants did not survive well on dry sites.

Fourwing saltbush plants achieved over 1 foot of height growth within 1 year after they were planted on alluvial flood plains.

Sharp-tailed Grouse Digest Corn and Buffaloberry Fruits Better Than Other Winter Foods

The percent of ingested energy that is metabolizable by sharp-tailed grouse from several winter foods was determined in habitat studies on the Buffalo Gap National Grasslands of South Dakota. Corn ranked highest and silver buffaloberry was second in metabolizable energy among six food items tested. There were also differences in the amounts of each diet eaten. Energy is vital for body maintenance, temperature, and growth of these important game birds, especially during the winter. Food plants such as corn and other cereal crops should be carefully considered when sharp-tailed grouse habitat improvement programs are being planned.

White-tailed Deer Grazing Capacity Estimated for the Black Hills

Estimates of white-tailed deer grazing capacity for the Black Hills ranges are becoming more precise through the combination of artificial rumen techniques, knowledge of deer food preferences, and dry-matter production data. Representative sites were sampled to determine which browse species provided the greatest potential on deer winter range. Grazing capacities of the major shrub species are shown in the following tabulation.

Species	Dry matter production	*In vitro* digestibility	Deer days per acre
	(Pounds/Acre)	(Percent)	
Woods rose	25.5	65.9	8.4
Fringed sagebrush	23.7	45.0	5.4
Common snowberry	14.7	71.4	5.4
Quaking aspen	10.2	44.5	2.3
Chokecherry	4.0	56.9	1.2
Saskatoon serviceberry	3.8	48.1	.9

Energy values of sharp-tailed grouse dietary items and excreta were determined with a Parr Oxygen Bomb Calorimeter.

Thirteen Deer Habitats Identified in the Black Hills

Thirteen distinct deer habitat types within the ponderosa pine forests of the Black Hills have been defined by computer analysis of vegetation, soil, site, and deer use data. An analysis of long-term averages of deer pellet group densities in sample stands shows that white-tailed and mule deer herds concentrate on two habitats during two critical seasons of the year. The bur oak-low Oregongrape habitat is a foothills winter range area. Deer use the western snowberry-Kentucky bluegrass habitat almost exclusively in April and May; this habitat is very important to deer as they regain body condition after the prolonged winter stress period.

Annual clipping of 50 percent of each twig on the bitterbrush plant at right resulted in a shorter, more dense shrub which had longer leader length but which had about the same total production as the unclipped bitterbrush plant at left.

Bitterbrush Shows Variable Response to Cultivation and Clipping

Cultivation to remove competing vegetation and/or clipping 50 percent of each twig to simulate moderate deer browsing had a highly variable effect on bitterbrush planted on a burned site in the central Black Hills. Conclusions after 5 years of treatment are (1) sustained production of bitterbrush can be expected when these plants are moderately browsed by deer, and (2) removal of competing vegetation is not necessary for sustained bitterbrush production on similar old burn sites in the Black Hills.

Cultivated-clipped plants exhibited the least height growth, the greatest individual twig length, and the greatest decrease in twig number.

Cultivated-unclipped plants and uncultivated-clipped plants reacted similarly. Uncultivated-unclipped (control) plants showed about the same height growth as did the cultivated-unclipped and the uncultivated-clipped plants, but the control plants had less individual twig growth.

Mule Deer Prefer Forbs and Grasses

Winter grazing studies with tame mule deer on sagebrush ranges in central Colorado revealed that deer prefer forbs and grasses over sagebrush. Forbs and grasses comprised over 90 percent of the deer diets on crucial winter range—southerly slopes where deer congregate to avoid deep snow. During two winters of study, big sagebrush comprised only 2.6 percent of the deer diets, and most of it was taken where the snow was over 1.5 feet deep.

Southerly slopes produce little forage because of poor growing conditions and overuse. Herbage yields on such sites were increased over 20 percent by applying 30 pounds of nitrogen per acre; a 70 percent herbage increase was achieved by applying 120 pounds of nitrogen per acre. These studies, conducted in cooperation with the Colorado Game, Fish and Parks Division and the Colorado Cooperative Wildlife Research Unit, also suggest that careful use of 2,4-D herbicide with fertilizer can improve the vegetative composition of these important areas for deer grazing.

Small Pastures Within Arizona Chaparral Improve Mule Deer Habitat

Forb and native grass production was four times greater within 80-acre pastures of weeping lovegrass than within surrounding chaparral areas of shrub live oak and skunkbush. Mule deer used the pastures less than the chaparral areas, but the superior quality and quantity of forbs and grasses within the pastures compared to the poor quality of the chaparral shrubs may compensate to some degree for less deer use within the pastures.

Competition Between Elk and Livestock May Be Critical

Grazing ranges for elk and livestock greatly overlap on the south end of the Medicine Bow Range in south-central Wyoming. Cattle and sheep graze areas during the summer that are used as feeding sites by elk during the fall, winter, and early spring. Elk movements in the spring and fall are largely determined by weather conditions, and elk do not stay in areas where livestock have harvested most of the available forage. Following heavy snows, elk move to south- or west-facing slopes, ridgetops, or areas of naturally low snow depths.

Our research during the last 3 years indicates that elk winter food supplies can be increased by regulating cattle grazing on critical elk feeding sites. Salting and water development for cattle to encourage their use of ridgetops and south slopes may not be desirable on sites that provide key winter elk habitat.

Forage Production and Nutritive Values Determined for Elk Feeding Sites

Our elk habitat research project in southern Wyoming is determining the plants eaten by elk, the nutritive value of those plants, and elk distribution patterns. Diets for elk on winter feeding sites contained 75 percent grasses and grasslike plants, 22 percent shrubs, and 3 percent forbs. During this critical period, *in vitro* digestibilities for grasses, forbs, and big sagebrush using elk inoculum averaged 43, 44, and 56 percent, respectively. Comparative tests of the same plants using inoculum from a fistulated steer indicated slightly lower digestibilities. Inoculum from different elk showed that plant species within the rumen vary from site to site. The percentage composition of graminoides, forbs, and shrubs were quite similar, however.

Digestion coefficients were determined by using elk inoculum on forage samples collected in August and September. Digestion coefficients for grasses and grasslike plants ranged from 57 percent for Ross sedge to 36 percent for prairie Junegrass, with an average of 46 percent. Forb digestion coefficients ranged from 71 percent for thistle to 29 percent for sulfur buckwheat, with an average of 58 percent. Shrub digestion coefficients ranged from 56 percent for aspen to 31 percent for grouse whortleberry, with an average of 48 percent.

Mule Deer Practice Natural Rotation of Heavy Use in Pinyon-Juniper Woodlands

Mule deer on the Fort Bayard Experimental Area in southwestern New Mexico concentrate their feeding activities on specific areas of browse within the pinyon-juniper woodland. The same area is seldom used heavily during 2 consecutive years. Deer practice natural rotation by selecting new sites for heavy use from year to year.

Deer population density affects the amount of heavy use. The portion of the Experimental Area that is heavily used may range from 5 percent with a population of 12 deer per section to 20 percent with 20 deer per section.

Desert Mule Deer Do Not Compete with Cattle for Winter Forage

Most of the plants which comprise the bulk of desert mule deer winter diets on the Santa Rita Experimental Range in southern Arizona are not of great importance to cattle. Barrelcactus fruit and false-mesquite calliandra leaves comprised 48.5 and 25.0 percent, respectively, of the deer diets. Other important deer food items included cholla fruit, mesquite leaves, catclaw acacia leaves, and mescat acacia leaves.

Small Clearings Provide Most Mule Deer Forage in Central Rockies

Small clearcuts in the lodgepole pine and spruce-fir forests of the Central Rockies have definite advantages as mule deer habitat. Clearings received twice as much deer use and contained twice as much forage 12 to 15 years after logging as did areas of virgin timber. About 15 to 20 forage species were common in clearcuts, while only two species were common in the uncut forest. Given an equal opportunity to graze in clearings and in the forest, the tame deer used in our experiment spent 70 percent of their grazing time in clearings.

An observer following a tame deer records on tape the number of bites of each plant species taken by the deer.

Winter Forbs Provide Supplemental Phosphorus for Mule Deer in Arizona Chaparral

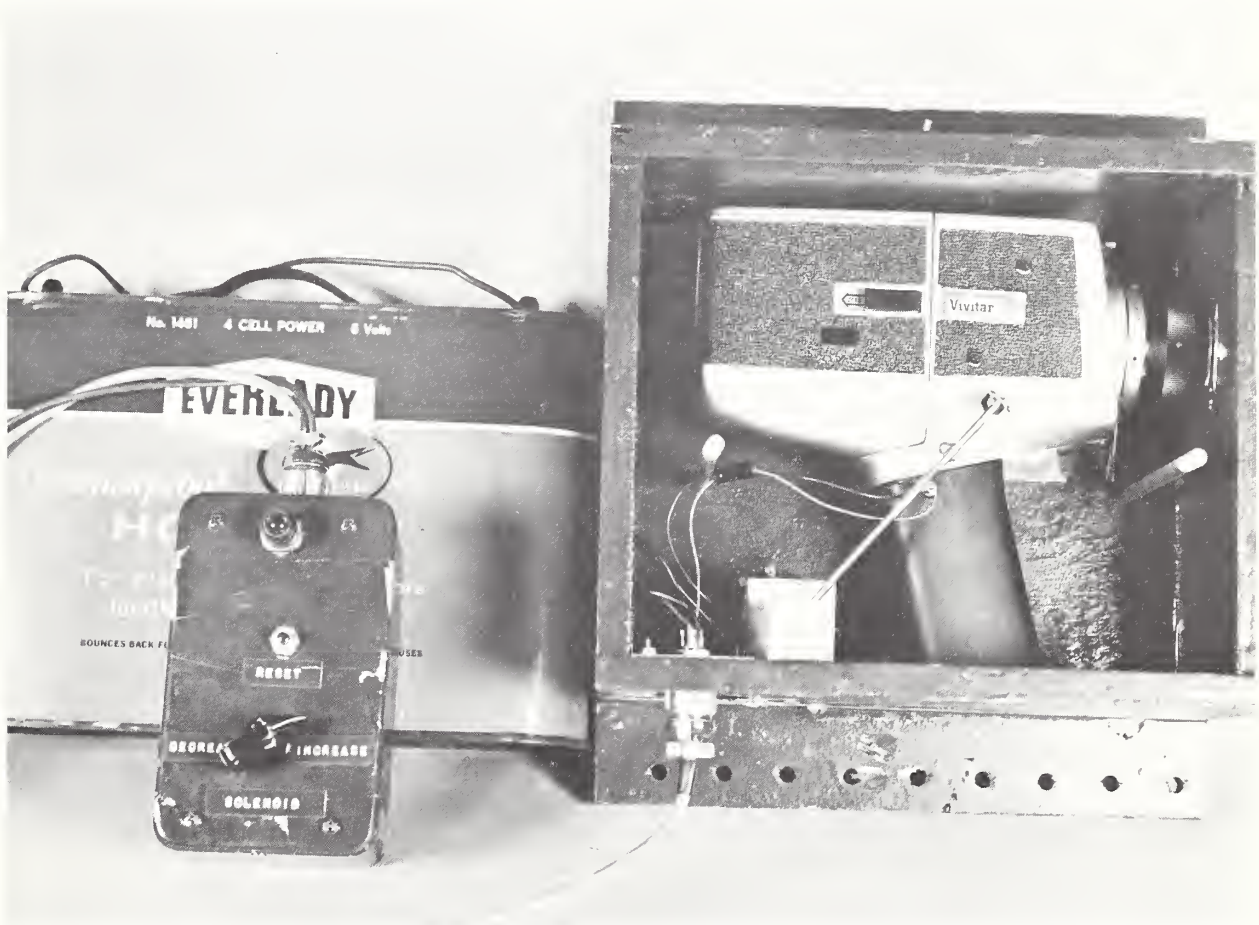
Phosphorus is deficient in most chaparral browse during the winter when mule deer depend heavily upon browse. Winter-growing forbs such as Louisiana sagebrush, bigroot, purplehead grassnuts, and tuber anemone provide variety in the diet, and they supply phosphorus that compensates for the lack of phosphorus in winter browse.

Grazing period	Forbs		Chaparral browse	
	Phosphorus content	Diet composition	Phosphorus content	Diet composition
	(Percent)			
Oct.	0.22	61	0.19	27
Nov.-Dec.	.29	38	.17	47
Jan.	.43	28	.14	61
Feb.-Apr.	.40	36	.23	44

Time-Lapse Camera Records Wildlife Habitat Use

We have developed a time-lapse camera which can selectively record wildlife use on key habitat areas. The unit consists of an 8 millimeter camera encased in a weatherproof box. A single frame release is activated by a solenoid connected to an electronic timer which can be set at intervals from 2.5 to 20 minutes. Light energizes a solar cell to turn the camera on at dawn and off at dark. One roll of super 8 millimeter film (3,600 frames) will last for 40 days when the timer is set at 8-minute intervals and daylight averages 12 hours.

Exposed film is examined by using a low-power binocular scope over a light table. Individual frames may be examined in detail to determine species, numbers, and environmental conditions. Exclusive of labor, the complete time-lapse camera unit can be built for less than $200.



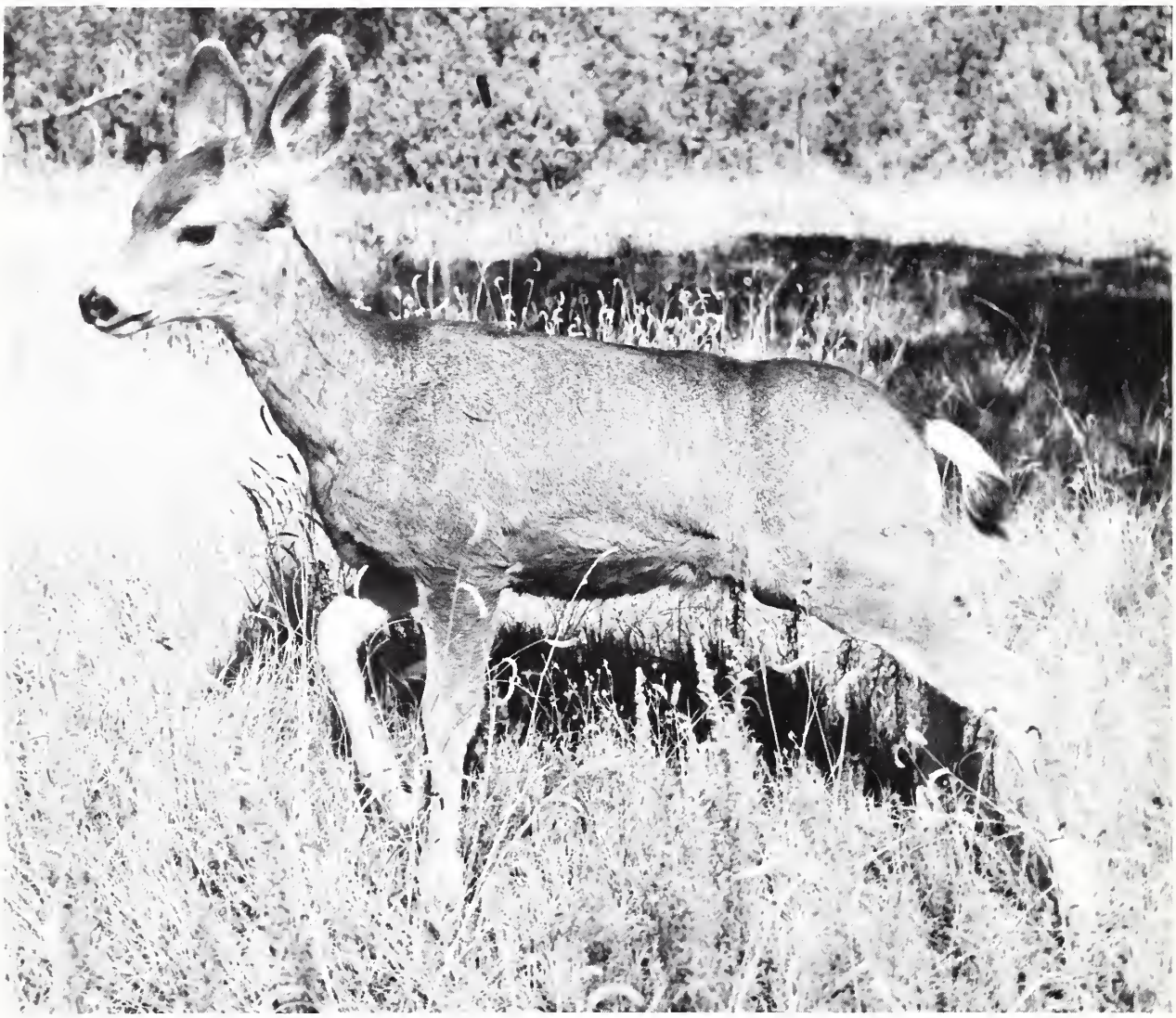
A time-lapse camera developed for recording wildlife habitat use.

Forbs Important for Mule Deer in Pinyon-Juniper Woodlands

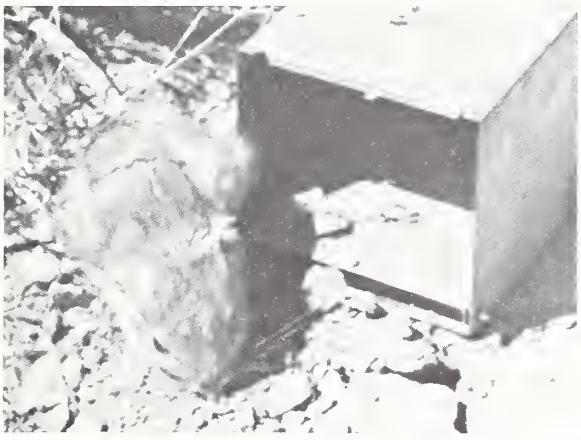
Forbs provide a welcome variety in mule deer diets, and these plants should be encouraged in the pinyon-juniper woodlands of southwestern New Mexico. Forbs comprise about 40 percent of mule deer diets during the spring and summer. The remainder of their diets during the spring and summer and their entire diets during the fall and winter are made up of staple browse species such as oak, mountainmahogany, Wright silktassel, and skunkbush.

Some species of forbs are preferred over others. Preferred forbs are those of the *Commelina, Desmanthus, Dalea,* and *Lotus* genera. Abundant forbs that are ignored by deer include those of the *Mirabilis, Eriogonum,* and *Sphaeralcea* genera.

An unusual quantity of quality forbs is produced when rainfall from December through March is above average. During such a year in 1968, forbs comprised 65 percent of mule deer diets. A shift of utilization from browse to forbs permits some physiological rest for the browse species.

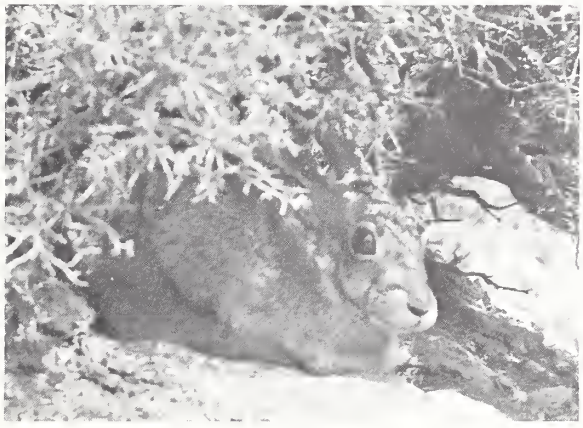


Forbs are important to the diet of mule deer in the pinyon-juniper woodlands of southwestern New Mexico. Forbs provide welcome dietary variety when available in spring and summer, and browse plants benefit by being relieved of grazing pressure.



A

B



C

Kangaroo rats (A), white-tailed prairie dogs (B), and black-tailed jackrabbits (C), inhabit the sparsely vegetated watersheds of the salt-desert shrub type, Badger Wash Experimental Area, Colorado.

Various Species of Herbivorous Mammals Inhabit Salt-Desert Shrub Range

Eleven species of small mammals, including nine rodents and two lagomorphs, were identified in the salt-desert shrub type of the Badger Wash Experimental Area in extreme western Colorado. Rodents caught in traps were Apache pocket mice, deer mice, northern grasshopper mice, piñon mice, western harvest mice, desert wood rats, Ord's kangaroo rats, white-tailed ground squirrels, and white-tailed prairie dogs. Lagomorphs counted in censuses were desert cottontails and black-tailed jackrabbits.

Populations of these animals are being investigated to determine their relative abundance on ungrazed watersheds and on watersheds grazed by livestock in winter. The investigation is one part of a cooperative study being conducted by four governmental agencies to compare vegetation, runoff, and sediment yields among ungrazed and grazed watersheds in the sparsely vegetated salt-desert shrub plant community, which is recognized as a major sediment contributor to downstream drainages.

Northern Pocket Gopher Population High in 1970

The 1970 fall population of northern pocket gophers on grazed ranges within the Black Mesa Experimental Forest and Range, Colorado, was about 30 per acre. This number is equal to the 1968 fall population, and it is an increase over 1969 when the estimate was 17 gophers per acre. The population ranged from 16 to 30 and averaged 21 gophers per acre during an 8-year period (1963-70). These figures probably represent the approximate range within which fall populations of northern pocket gophers normally fluctuate on this type of range.

The population dynamics of northern pocket gophers are being studied on this high-altitude range to learn about the relationship of this herbivore to range ecology and to other range users such as cattle, deer, and elk.

Bird Densities Studied on Sagebrush Watersheds in Wyoming

Sampling small birds near Saratoga, Wyoming, was intensified in 1970 to include an index of their breeding densities. Singing territorial male birds were counted within a 40-acre study site on each of two watersheds for three mornings in June. Data from these counts revealed that the Brewer's sparrow was the most abundant, with an average density of 211 breeding males per section. The vesper sparrow was second in abundance with 134 breeding males per section, and the sage thrasher was third with 19 breeding males per section. The green-tailed towhee, which was found breeding in 1969, was not observed during the 1970 census period.

Longevity Record Set for Northern Pocket Gophers

A male northern pocket gopher, first caught in the summer of 1966 as an adult on the Black Mesa Experimental Forest and Range in west-central Colorado, was retrapped for the fifth successive summer in 1970. The probability is relatively high that this gopher was a first-year adult in 1966, and that he was actually 5 years old when last caught. This capture established a longevity record for northern pocket gophers in Colorado. Based on records obtained from live-trap, release, and retrap operations, and from age ratios of sampled populations, northern pocket gophers in Colorado usually have a relatively short natural life span of about 1.9 years.

Sage thrashers occupy the arid western sagebrush plains and use individual sagebrush plants for their nesting sites.

Procedures Standardized for West-wide Weather, Snow, and Avalanche Reporting Network

Standardized snow, weather, and avalanche data are being collected by national forest snow rangers and others at 21 stations throughout the western United States, including Alaska.

Total snow depth, maximum and minimum air temperatures, snowfall and its water equivalent, new snow crystal type, observations on snow structure, and an estimate of snow transport are recorded every morning for the previous 24-hour period. Windspeed and wind direction from an exposed ridge crest and precipitation intensity (when available) are recorded as 6-hour averages. In addition, all avalanche control actions and avalanches are documented and described in detail.

These data are used at ski areas to help determine when avalanche control measures are needed, and when cross-country touring should be restricted. The data are also compiled and analyzed for use in more formal and objective evaluations of avalanche hazard for both backcountry areas and developed ski areas.

About 2,500 avalanches have been reported during each year of record. During severe storms, as many as 120 avalanches were observed per day at one area. The largest avalanche reported occurred in Alaska. It ran for 2.25 miles and dropped 3,500 feet vertically. The air blast associated with the avalanche knocked down about 100 trees and injured two skiers. Approximately three-fourths of the avalanches reported were triggered artificially as part of organized avalanche control programs established to safeguard the public on the highways and at the ski areas. Avalanches have been reported from October 13 to May 27. About 35 percent of the winter's avalanches occur during January.

A typical study plot in the West-wide Weather, Snow, and Avalanche Reporting Network. Temperature and humidity instruments are in the white louvered shelter, which can be raised or lowered to keep it at a uniform distance above the snow. Precipitation gages are on the tower to the left. Snow depth stakes are in front of the instrument shelter and to the right of the precipitation tower. Windspeed and wind direction sensors are located on a nearby ridge crest so that they are not affected by local terrain.

"Weakest Link" Theory of Snow Fracture Being Developed

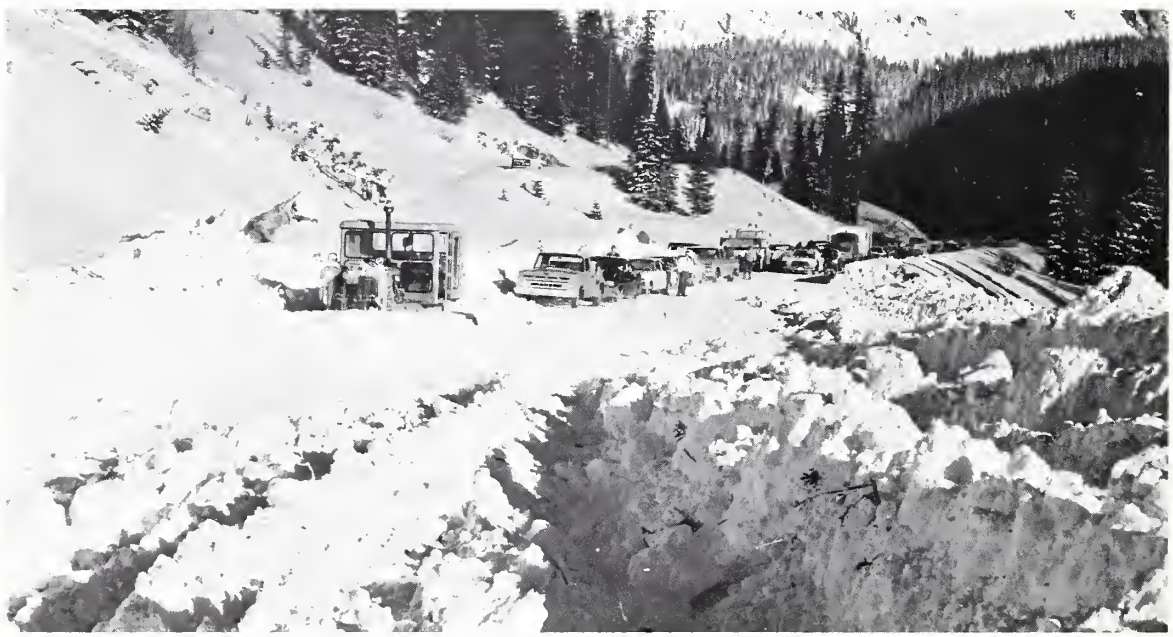
To understand when and where snow avalanches will occur, we must first understand the conditions that cause the snow cover to fracture or fail. It is fairly simple to determine, for a piece of steel, the amount of stretching or bending that results from a given load and the ultimate load needed to break the sample. Unfortunately, the snow cover on a steep mountainside does not lend itself to such a simple, direct experimental approach. Instead, a combination of theoretical considerations and field experiments are being used to develop a method for predicting the conditions under which a snow cover will fail.

The first crude model of mechanical snowpack properties considered them to be similar to those of a simple spring where deformation is directly proportional to load. In spite of the crudeness of the model, calculated stresses were encouragingly accurate. A more sophisticated model is now being prepared for the computer, and it will be used to improve the accuracy of deformation calculations. In addition, newly developed instruments will be embedded in the snow cover to measure actual deformations as a function of load increases, determined by changes in snow depth.

Work toward a failure criterion is promising. The large scatter in strength measurements on snow samples of the same density is consistent with the idea that snow acts as a brittle material. In such materials, stresses tend to concentrate around flaws, and failure occurs when local stress concentrations cause the flaws to enlarge rather than when the average stress exceeds the basic strength of the material. The larger the flaw, the greater the stress concentration, and the weaker the sample. Thus, a particular sample of brittle material is only as strong as the weakest flaw which the sample happens, by chance, to include. Hence, the failure criterion for such brittle materials is often called the "weakest link" theory of failure.

Scattered as they are, the strength data for snow show a maximum strength for a given density. Further analysis of data from two sites—one in Colorado, the other in Utah—shows that the probability that a given sample of snow will fail increases as the load applied to the sample approaches the maximum strength for snow of that density. Since the snow from the two sites behaved alike, we do not believe that temperature (as long as it is below freezing) and crystal type are of prime importance in establishing a failure criterion for snow.

From the data we now have, a curve has been constructed that gives the failure probability of a snow sample if snow density and the applied load are known. Continued work will be needed, however, to extrapolate these results to the much larger volumes of snow representative of the snowpacks in avalanche paths.



A failure in the snow cover high on the mountain was an important step in the chain of events that resulted in this avalanche which blocked U. S. Highway 6 west of Denver, Colorado. A failure criterion based on the "weakest link" failure theory for brittle materials offers hope for predicting the likelihood of such events.

Model Developed for Revising Streamflow Forecasts

In the Rocky Mountain West, water users rely on snow surveys to predict streamflow during the spring and summer. These forecasts are generally made when winter snow accumulation has reached its peak, and they are contingent on the assumption that the snowmelt season will be normal. Experience has shown that water supply forecasts based on early spring snow surveys become less reliable when precipitation and other weather conditions deviate appreciably from normal during the melt season.

To accurately revise streamflow forecasts, we are developing a model which is flexible enough to account for unusual precipitation and weather conditions once the melt season begins. The procedure is based on (1) aerial photographs showing the change in snow-covered area during the melting period, and (2) a precipitation index computed from early spring snow survey measurements **and** snow and rainfall received **during** the snowmelt season.

The areal extent of snow cover is a useful forecasting variable because the snow disappears in the same patterns each year, regardless of the amount of winter snow accumulation. Moreover, the decrease in horizontal extent of the snow cover is highly correlated with the increase in streamflow. Thus, estimates of snow coverage during the melt season provide the means for forecasting runoff subsequent to the snow cover determination.

Knowing the amount of runoff accumulated at the time of the snow cover measurement, the forecaster can estimate the residual flow using characteristic relationships developed from past seasons. The precipitation index is used to adjust the forecast up or down, depending on the amount of precipitation received up to the time the forecast is made.

One problem we have encountered is that the forest cover on large basins hinders visibility of the snowpack from aircraft. Also, it is not feasible to map large drainage basins accurately from aerial photographs. Accordingly, we are making photogrammetric measurements in smaller key areas where the snow cover is visible, and where the rate of depletion is representative of the larger drainage basin. This reduces the cost of flying, and enables the hydrologist to obtain a relatively quick and precise estimate of snow cover extent.

Photogrammetric measurements are made at the Colorado State University Engineering Research Center on a Wild STK-1 stereocomparator with punched card output. This instrument allows the operator to precisely delimit snow cover on the key areas by punching coordinates on cards. The relative area covered by snow is then determined from the coordinates by a computer.

Photogrammetric measurements of snow cover extent on key areas are made at the Colorado State University Engineering Research Center on a Wild STK-1 stereocomparator with punched card output.

Water Quality Studied at Fraser Experimental Forest

For an 11-week period in 1965, the streamflow of four watersheds in the Fraser Experimental Forest, Colorado, was sampled twice weekly in cooperation with Duke University. Samples were analyzed for calcium, magnesium, potassium, and sodium. There were significant differences between weekly streamflow cation concentrations within each watershed and among the four watersheds studied. Cation outflow, based on the last 5 weeks of record, totaled 13.1 pounds per acre from one watershed and 10.6 pounds per acre from another.

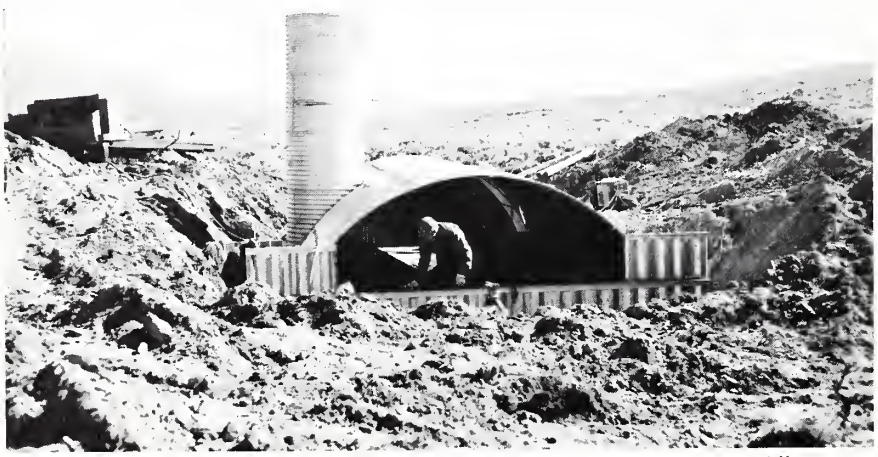
A comparison of the range in cation concentration indicates that sodium and potassium ion concentrations in 1970 were approximately twice those found in 1965. The present study is analyzing silica, alkalinity, dissolved oxygen, and conductivity in addition to the following ions: sodium, potassium, calcium, magnesium, nitrate-nitrogen, chloride, orthophosphate, and sulfate. During a week of intensive sampling in early August 1970, hourly and daily differences in sodium and potassium were less than the accuracy of the analysis limits of the flame photometer (± 0.5 p.p.m. for sodium and ± 1 p.p.m. for potassium). Dissolved oxygen during the same period averaged 73 percent of saturation (9 milligrams per liter) from both watersheds. Continued stream sampling through the 1971 snowmelt combined with precipitation sampling should give a preliminary picture of the chemical budget of these mountain watersheds on which to base further studies of the effect of management on water quality. This study should also identify specific ions whose behavior warrants research that will trace the processes influencing their concentration at the gaging site.

Covered Weir Developed for Streamflow Measurements Under Heavy Snow

The operation of stream gages under conditions of heavy snow and high winds is very difficult. Experience gained by covering a conventional V-notch weir with a multiplate arch led to the design of a weir completely contained within a pipe arch. Such a weir was constructed on the Stratton Sagebrush Hydrology Study Area in southern Wyoming.

A 120° V-notch was installed in an interlocking steel sheeting cutoff wall. Two sections of the multiplate pipe arch, comprising the stilling pond and apron areas of the weir, were placed upstream and downstream from the wall and bolted together. A standard U.S. Geological Survey instrument shelter of corrugated pipe was mounted over a special saddle on the pipe arch. Installation of a steel sheeting headwall and corrugated sheeting covers at the ends of the pipe completed the weir.

The contained weir not only protects the hydraulic performance of the stilling pond and control section, but also facilities escape of water downstream. It appears to be particularly suited to the measurement of snowmelt runoff in intermittent channels under conditions of heavy snow.



A contained weir under construction in southern Wyoming. All major components of the gaging station—pipe arch, cutoff wall, headwall, end cover, and instrument shelter—are shown. The gage is well suited to conditions of heavy snow.

Automatic Camera Used to Record Winter Weather Events

An automatically operated camera is being used to record winter weather events at the Fraser Experimental Forest, Colorado. Snow is quickly cleared from tree crowns as shown by the accompanying photographs. Typically, a few hours after winter snowfall ceases, strong winds aloft interact with the mountains to generate vortexes and eddies that quickly strip snow from exposed foliage.

This photograph was taken during moderate snowfall that continued throughout the day on February 4, 1970 at the Fraser Experimental Forest. The storm ceased during the night.

The most exposed trees were already bare of snow by noon on February 5, 1970. Individual vortexes look like artillery bursts on the mountainsides. Vortexes were moving rapidly eastward (from right to left), and each one was visible for less than 60 seconds.

By 4:00 p.m. on February 5, 1970, all snow was gone from exposed tree crowns. The white patches are snow in the clearcut blocks on the upper portion of the Fool Creek watershed.

Snow Fence Tested in Wyoming

Snow fences have long been used to protect highways, railways, and buildings from unwanted snow accumulations. In cooperation with the Medicine Bow National Forest, we are testing a snow fence designed to increase water yield from the Pole Mountain watershed in southeastern Wyoming. A fence 12.5 feet tall and 1,300 feet long was built to trap the snow that blows across this windswept watershed. During the 1969-70 winter, snow accumulation behind the fence was about twice that expected on the watershed without the fence. Studies over several years will determine the effects of increased snow accumulation on the amount and timing of water yield.

Amounts of blowing snow, sampled by snow traps in front of the Pole Mountain snow fence, are being related to snow accumulation behind the fence.

Blowing snow and cornice development behind the Pole Mountain snow fence.

The Pole Mountain watershed on the Medicine Bow National Forest, Wyoming. A: Peak snow accumulation in 1969 before the snow fence was built. B: Peak snow accumulation behind the snow fence in 1970.

Airflow in a Lodgepole Pine Forest Being Studied

An understanding of the airflow patterns in an undisturbed forest is needed before we can understand how cutting trees will affect airflow over and through a conifer canopy. Since any natural tree stand is a random collection of obstructions to airflow, we can deal in a practical manner only with averages in time and space.

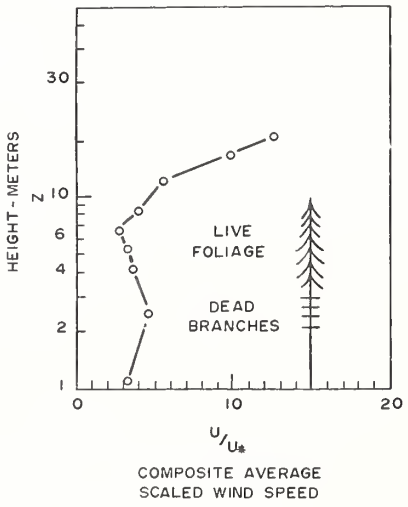
Our site for this study is a level and uniform stand of lodgepole pine near Fox Park, Wyoming. The trees are about 80 years old, and average about 10 meters in height. Profiles of windspeed were measured at six levels within the canopy and at three levels on a control tower above the trees.

The time average windspeed profile at points between trees has been measured at locations selected by certain rules near points on a geometric grid. When these profiles are scaled and weighted in the proper manner, we can form an average or "composite" profile over the points of measurement, which should correspond roughly to the average maximum speed in an area of the stand containing four trees.

The result is shown in the accompanying diagram, where Z is the height above the soil, and where the speed (U) has been expressed in terms of a unit of wind force at the top of the canopy (U*). The actual space average wind profile will lie somewhere between this profile and zero at any level, depending on the variation of speed in the horizontal between and through tree crowns, which is generally unknown and a problem for further study.

Aside from the magnitude of the scaled speeds, the shape of the composite profile is of immediate interest. The height of the minimum windspeed (6.5 meters) will be used with parameters calculated from the part of the profile above the trees to predict the effects of a clearing on the mass, momentum, and energy balance of the stand. The prediction will be based on the width of the cutting, and the results of wind tunnel studies of slots. A 10- by 60-meter cutting has been made with its longest dimension perpendicular to the prevailing wind. The windspeed distribution in this cutting will be compared with that found in a slot with a depth-to-width ratio of 6.5:10 to see what modifications may be made to relate the two flows.

Sampling lodgepole pine crowns in the field. After felling trees, branches from various sections of the crown were stratified into several size classes for preliminary measurements. Three or four branches were later selected from each size class for quantitative measurements.



Foliage and Branch Characteristics Determined for Lodgepole Pine

Tree crowns greatly influence windspeed profiles, and they thus significantly affect the distribution and redistribution of snow cover. Cut trees were measured in terms of bole diameters at various heights; branch diameters, lengths, weights, and positions; and needle weights. From these measurements, predicting equations were developed that can be used to estimate the quantity and distribution of needles and branches for standing trees.

Weight relationships between foliage and branches of lodgepole pine are highly correlated for lower, middle, and upper crown sections. Crowns are highly variable from tree to tree, but for most trees it appears that estimators for crown weights will include some combination of diameter at breast height and bole diameter at the base of live crown. Distribution of crown weights with tree height will be more difficult to predict, but it will depend on whorl location, branch diameter, and branch lengths. Our goal is to determine some easily measured characteristics of standing trees that can be used to predict the quantity and distribution of foliage and branches for individual trees or for an entire stand.

UPPER CROWN
Green weight of branches: 1,593 grams
Diameter of average branch: 0.30 inch
Length of average branch: 0.8 foot
Length of longest branch: 1.6 feet
Total tree height: 31.0 feet

MIDCROWN
Green weight of branches: 4,766 grams
Diameter of average branch: 0.39 inch
Length of average branch: 1.7 feet
Length of longest branch: 3.1 feet

LOWER CROWN
Green weight of branches: 3,069 grams
Diameter of average branch: 0.37 inch
Length of average branch: 2.0 feet
Length of longest branch: 3.3 feet

DEAD CROWN
Length: 5.8 feet
Diameter at Breast Height (d.b.h.): 4.0 inches

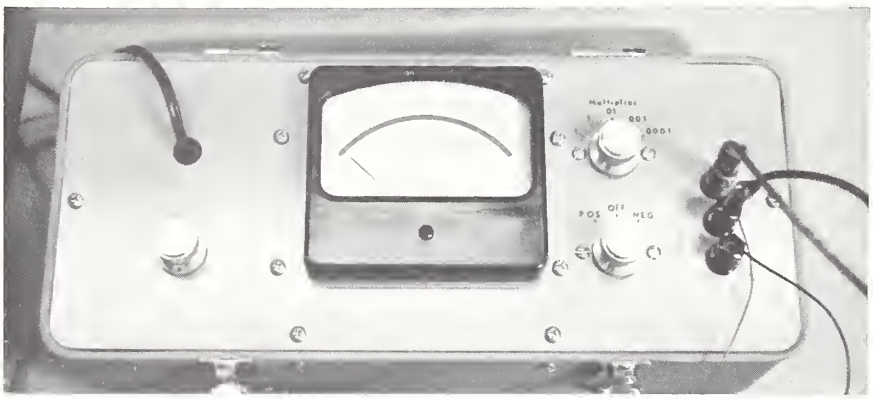
Composite photograph of a lodgepole pine near Fox Park, Wyoming. A remote control camera mounted on a telescoping mast was used to photograph sections of the tree. The tree was later felled and dissected.

Millivolt Integrator Developed for Radiation Measurements

Electronic integration of a radiometer's multivolt signal is a practical and accurate way to directly obtain cumulative measurements of solar radiation over a specified time period. An integrator recently designed and built by our scientists consists of four printed circuit boards, a synchronous bidirectional stepper motor, and a 5-decade counter. The integrator is calibrated to match the millivolt output of the radiation sensor so that the counter reads directly in total langleys for the time period between readings.

The integrator requires a heated instrument shelter because the integrated circuits and transistors used in the stepper motor driver circuit are somewhat temperature sensitive, and wet-cell batteries are needed for the external power source. The temperature range inside an unheated instrument shelter on the Castle Creek watershed in Arizona was about 55° F. while the range was only 8° F. with thermostatically controlled heat. The integrator percent of error over a 10° F. temperature range is at the most only ±1 percent. The error is as much as ±8 percent over a 55° F. range.

The voltage integrator sums the millivolt signal from the Eppley pyranometer directly in langleys and displays it on a 5-decade counter. It can be read over any time period from 5 minutes to several days.



This voltage divider will accurately calibrate the voltage integrator for a given radiometer. It allows long-term calibration checks with constant (±.0025 percent) millivolt inputs that simulate the output from a radiation sensor.

Streamside Chaparral Conversion to Grass Increases Streamflow

Increased streamflow has been noted for 3 successive years since a streamside strip within a central Arizona watershed was chemically treated to convert chaparral cover to grass cover. Thirty-eight acres along the main channels of the 246-acre Whitespar B watershed were treated in March 1967. Prior to treatment, the channel was dry several months each year. Since treatment, flow has been continuous at the outlet, and water has been permanently available for wildlife and livestock at several places along the channel.

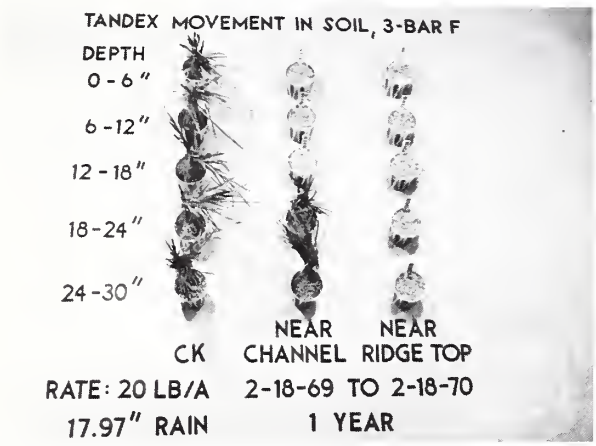
The increase in streamflow from the entire watershed for the 3 posttreatment years was estimated at 0.63, 0.97, and 0.57 area inches. All of the increase is assumed to come only from the treated area. The increase from the 38 treated acres was about 4.1, 6.3, and 3.7 area inches for the 3 posttreatment years. About 80 percent of the increase occurred from January through March. Thus, most of the increase in flow occurs during the dormant season when evapotranspiration losses are low.

Tandex Herbicide Penetrates Sandy Ridgetop Soils More Rapidly Than Fine-Textured Channel Bottom Soils

Granular Tandex was applied by helicopter on the 68-acre 3-Bar F watershed in central Arizona to eradicate chaparral brush prior to converting the area to perennial grasses. Tandex was applied at the rate of 20 pounds active ingredient per acre.

Persistence and leaching characteristics of Tandex on the watershed are important in relation to soil and water contamination, brush control, and grass establishment. Leaching of Tandex into the root zone of the brush by precipitation is a necessary first step in controlling the brush. Excess leaching can result in poor brush control and an increase in the amount of herbicide entering the stream. Soil properties, herbicide properties, and precipitation amounts are determining factors.

Bioassay soil tests showed that Tandex penetrated the sandy soils near a ridgetop more rapidly than it did the finer textured soil near a channel bottom, which has a higher clay and organic matter content. After 5.69 inches of rain during the first 4 months after treatment, Tandex was detected in phytotoxic amounts throughout the top 24 inches of soil near the ridgetop and to a depth of 18 inches near the channel bottom. One year after treatment and after 17.97 inches of precipitation, phytotoxic amounts of Tandex were present to a depth of 30 inches on sites near the ridgetop, and to a depth of 18 to 24 inches on representative sites near the channel bottom.



Tandex herbicide moved into soils on the 3-Bar F watershed more rapidly in sandy soil near a ridgetop than in finer textured soil near a channel bottom. A soil bioassay test with oats as the indicator plant was used to detect the presence of the herbicide after 17.97 inches of precipitation during the first posttreatment year.

The two tubes on the left are lasers with collimating telescopes in place, while the two tubes on the right are mounts for filters and detectors. The wavelengths emitted by the lasers are selected such that one is absorbed by water vapor and the other is not. The difference between the two is a measure of the water vapor in the beam path. The two black boxes on the right supply power for the lasers. The fan used to circulate the enclosed atmosphere is to the right of the cylindrical test chamber. These laboratory trials will provide the knowledge needed to adapt lasers for precipitation measurement over a forest canopy.

Laser Beams Used in Development of Long-Path Hygrometer

Laser beams show promise for measuring precipitation and evapotranspiration over a forest canopy. The use of lasers to measure precipitation over a long path should yield a more accurate understanding of the amount of water falling on an area than do point measurements. Measurement over two paths at different heights should give a gradient and, therefore, a precipitation amount. We are hopeful that laser precipitation measurements will correlate with actual streamflow measurements. A calibration system for long-path laser measurements of atmospheric water vapor content is being developed. The system is illustrated by the accompanying photograph.

Computerized Forest Management Being Tested on Black Hills National Forest

Three computerized procedures that assemble and correlate data for timber management decisionmakers are being given a 2-year field test on the Black Hills National Forest. The procedures provide:

1. Yield tables for numerous combinations of site quality, thinning frequency, thinning intensity, and other variables.

2. Simulated changes in the forest or its economic surroundings that can be used to select management goals and prescribe methods for achieving those goals.

3. Complete management plans prepared from forest inventory data and information obtained by the other two procedures.

The procedures make it possible for forest managers to consider a wide range of information and many alternative actions with speed and relative ease before decisions are made. In addition, more intensive, flexible, and responsive management can be practiced because plans can be updated annually or more frequently if needed.

The Research and National Forest System branches of the Forest Service, U.S. Department of Agriculture, are being assisted by the College of Forestry and Natural Resources at Colorado State University. The Forest Supervisor and his staff are presenting data and questions as though the procedures were actually in use. A CSU data analysis group processes requests from the National Forest, carefully notes problems and limitations that appear, and determines the best methods for storing and retrieving data for the procedures being tested.

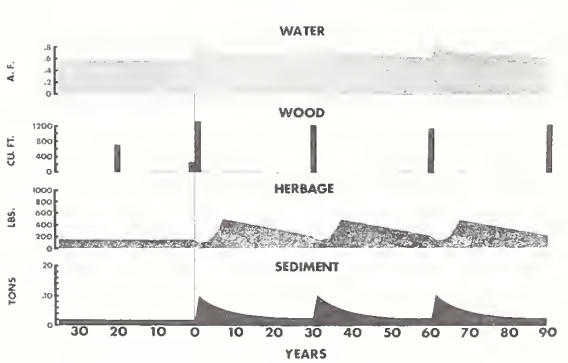
Timber is only one of several resources that can be analyzed by computer; it will be possible to include other resources as information becomes available. For example, soil factors that help predict tree growth can also be used to estimate forage production. Non-numerical analysis is also a possibility; forests being evaluated for timber production can also be described and rated by their esthetic appeal and recreational potential.

New Investment Model Automates Time Analysis

A computer model called the "Discounting Analysis Model for Investment Decisions" (DAMID) has been developed. The model discounts benefit and cost flows for up to 10 user-determined interest rates. Outputs of the program include discounted values of each individual cost or benefit, a summed net present value for the entire project, and project benefit-cost ratios for each interest rate used. The program has the capability of accepting an unlimited number of projects with a large number of flows within each project, and it will interpolate values for years for which no data have been supplied.

Multiple Use Effects Projected for Watershed Treatments

The accompanying illustration presents preliminary projections of water, wood, herbage, and sediment yields before and after treatment of a ponderosa pine watershed. The pretreatment and initial response data are from an actual stripcutting treatment on the Beaver Creek Watershed in Arizona. The remaining data are estimated, to show expected fluctuations in yield following successive cuts at 30-year intervals. Response is expected to differ among different treatments and among areas receiving different amounts of precipitation and having different vegetational and topographic characteristics.



Projections of water, wood, herbage, and sediment yields before and after a ponderosa pine watershed in Arizona is treated at years 0, 30, and 60.

Economic Model Evaluates Alternative Chaparral Management Practices

East Sycamore Creek, a small watershed on the Tonto National Forest in Arizona, was used to develop a model that will soon be available for evaluating alternative management practices for chaparral areas of the National Forest.

Economic value is one of the criteria used to evaluate the relative effectiveness of each of 13 different management alternatives. Other criteria include political, social, and institutional considerations. The identified products explicitly considered are range, water, recreation, fire reduction, wildlife, and environmental quality.

In selecting alternatives, an attempt was made to cover a broad cross section of feasible management possibilities. A range of vegetative patterns, possible chaparral control methods, and different treatment and maintenance combinations are included.

An economic model for evaluating alternative chaparral management practices has been developed for use on the Tonto National Forest, Arizona.

Forest Insects

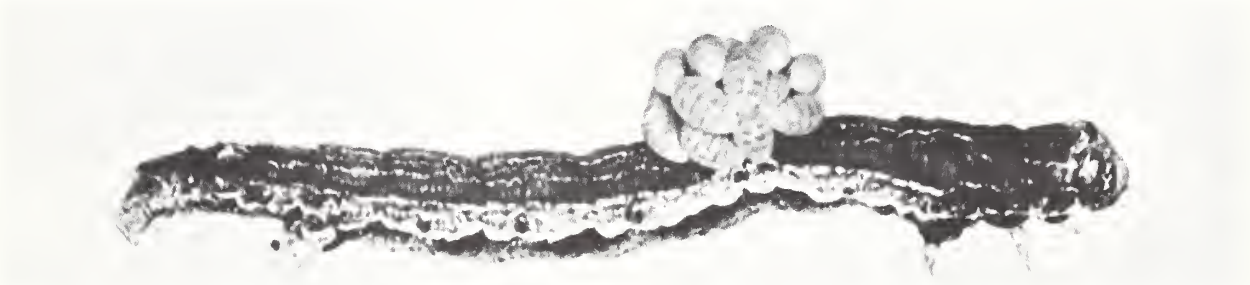
Cankerworms Threaten Shelterbelts in the Northern Great Plains

Defoliation by the spring cankerworm *(Paleacrita vernata* (Peck)) and the fall cankerworm *(Alsophila pometaria* (Harris)) has dramatically increased during the past 2 years in North Dakota and South Dakota. In 1970, the cankerworms completely defoliated many shelterbelts, especially single rows of Siberian elm.

Loss of tree vigor from repeated defoliation in several consecutive years may cause dieback and, eventually, tree mortality. Large gaps in shelterbelts reduce their effectiveness in preventing soil erosion and crop desiccation. Farmers may lose their dollars invested in trees, and they may receive less cash return from crops adjacent to defective windbreaks.

Natural enemies may be able to terminate these cankerworm outbreaks. A wasp, *Eupletrus hircinus* (Say), is numerous in some populations of spring cankerworms. This gregarious parasite lays several eggs on each cankerworm it attacks. The eggs hatch, and the larvae feed on and eventually kill the cankerworm.

Spring cankerworms, numbering 30 per 100 cubic feet of crown volume, defoliated this Siberian elm, leaving only leaf petioles on the branches.



The larvae of the wasp, Eupletrus hircinus, *kill the spring cankerworms to which they are attached.*

Many single-row shelterbelts of Siberian elm have been seriously defoliated by spring cankerworms in the northern Great Plains.

Spruce Beetle Egg Production Varies with Status of Infestation

Insect populations vary in response to many factors. Under certain conditions, insects are especially aggressive, causing much more damage per individual than at other times. One undesirable response is increased egg production per parent, which results in greater numbers of progeny in the next generation. Research on the spruce beetle (*Dendroctonus rufipennis* (Kirby)) has shown that egg production per beetle is higher during outbreaks than when populations are at low levels. The reasons for the differences are unknown, but they may include such factors as nematodes, variable host resistance, and genetic changes within the beetle population.

High Proportion of Spruce Beetle Parent Adults Reattack

Spruce beetles (*Dendroctonus rufipennis* (Kirby)) attack living trees in pairs—one male and one female per gallery. Sometimes the females emerge after completing their first egg gallery and attack again. The frequency with which this happens is important in understanding beetle population dynamics, and it has practical significance with respect to control operations. Preliminary laboratory studies on the spruce beetle showed that four of five female beetles reattacked, and some laid up to 50 eggs during the second attack. Further field studies will show how these laboratory results relate to natural conditions, and they will enable forest entomologists to better predict the course of spruce beetle infestations.

Method Developed for Estimating Budworm Defoliation

The western spruce budworm (*Choristoneura occidentalis* Freeman) is one of North America's most widespread and potentially destructive forest pests. Surveys are conducted each year in areas where the budworm is known to exist, and population densities are evaluated. The number of insects alone, however, does not tell the land manager the whole story; he also needs to know how much defoliation has taken place. We have developed a method that will provide both kinds of information from a single sample, thus eliminating one trip to the area concerned. The percentage of undamaged shoots on foliage samples collected for egg mass information also provides data for a reliable estimate of budworm-caused defoliation.

Cacodylic Acid Effectively Controls Bark Beetles

Mountain pine beetles (*Dendroctonus ponderosae* Hopkins) continue to cause heavy tree losses throughout the West, and control methods that are cheaper, safer, and more reliable are needed. A new approach for some situations is the use of a herbicide, cacodylic acid, as a systemic insecticide. The material, applied to trees through a frill near the ground line, moves up the trunk in the sap stream. Once in the tree, the acid appears to change the underbark environment so that beetles are unable to survive and produce progeny. Refinements in dosage and timing are still needed, but it looks certain that this new approach can, in some instances, give land managers a new method for bark beetle control.

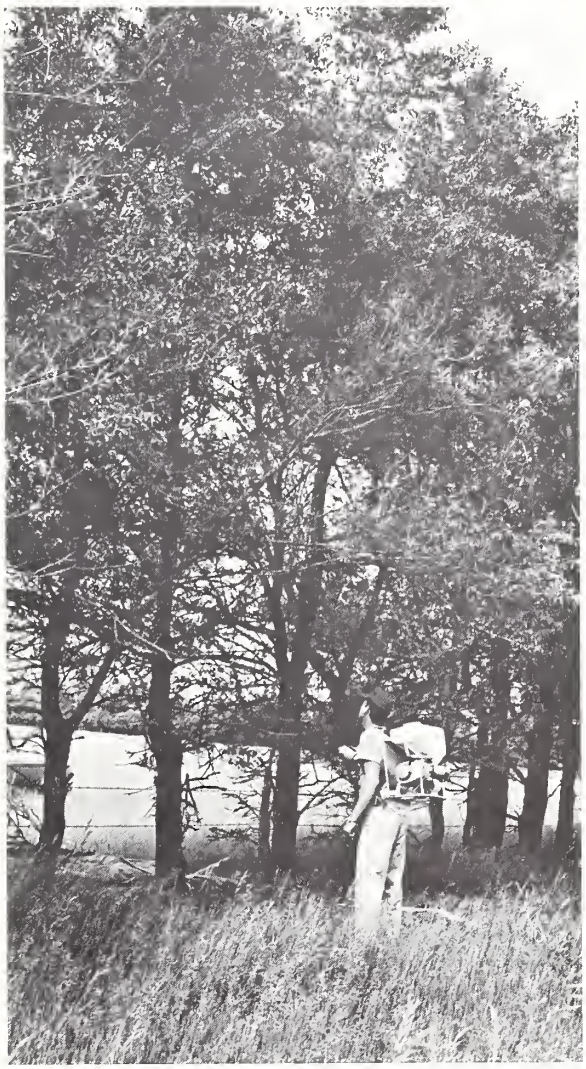
Cacodylic acid, applied to a frill near the base of the tree, controlled mountain pine beetles.

Pyrethrin Used to Sample Defoliating Insects in Shelterbelts

The "whole tree" sample method is being used to determine the number of defoliating insects present in the crowns of sample trees in North Dakota shelterbelts. These counts are compared to counts from smaller sample units that are more efficient for insect surveys.

Four branches, each one-half meter long, are cut from the crown of the tree to be sampled. Then the tree is sprayed with a solution containing 0.03 percent pyrethrin, a botanical insecticide which breaks down quickly in sunlight and leaves no harmful residue. Larvae in the tree crown become paralyzed, and they fall onto a mat beneath the tree within minutes. The number of larvae on the branches can then be correlated with the number of larvae collected from the whole tree.

These sampling methods can be used to relate insect abundance to tree damage. For example, the number of cankerworms per 100 cubic feet of crown volume increased from 1 in 1969 to about 30 in 1970. Defoliation increased from a trace amount to complete loss of leaves during the same period.



A mist blower is used to apply the pyrethrin spray which quickly paralyzes the larvae on the tree. The larvae fall onto a collection mat under the tree.

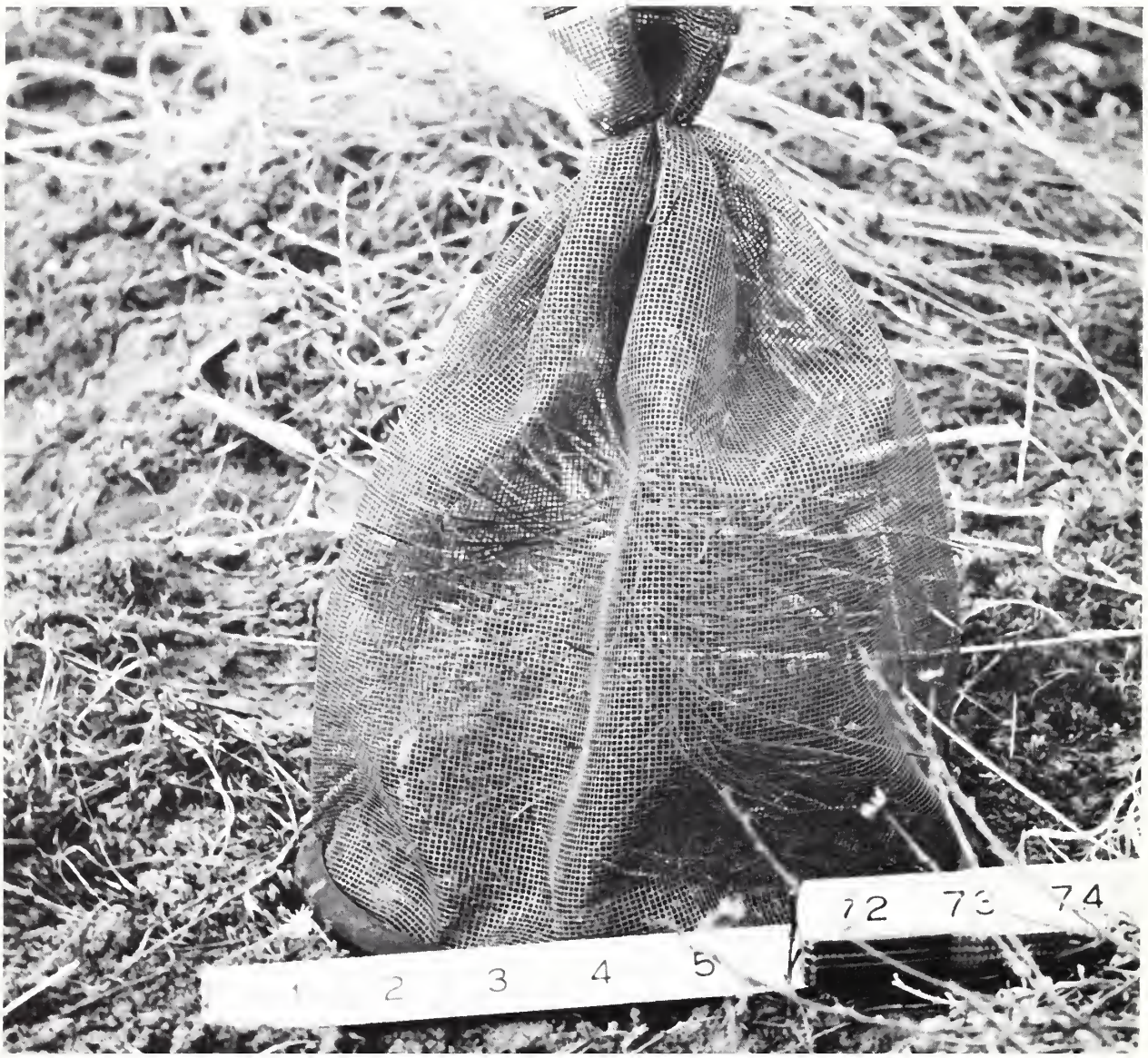
A Siberian elm 15 feet tall may yield as many as 5,000 spring cankerworms.

Ground Cage Used to Collect Southwestern Pine Tip Moths

The southwestern pine tip moth *(Rhyacionia neomexicana* (Dyar)) attacks both planted and natural seedlings of ponderosa pine. Affected trees have a distorted form and an impeded growth rate.

The tip moth overwinters in pupal cases attached to ponderosa pine seedlings below the ground level. The adult moths emerge in the spring. They mate, and the females lay eggs on the inner surface of the previous year's needles. To determine emergence dates of moths for research and survey purposes, ground cages were constructed from surplus food cans and fiberglass screening. The cages were placed directly over seedlings in plantations and pressed into the soil.

Adult tip moths began emerging April 4 on the Chevelon Ranger District, Arizona. Males emerged first, followed by the females an average of 10 days later. Emergence of both sexes continued until April 30.



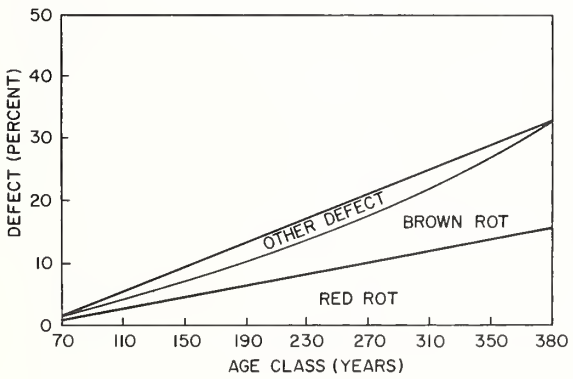
Ground cages constructed from surplus food cans and fiberglass screening were used to determine emergence dates of southwestern pine tip moths in Arizona. Adult tip moths emerge from overwintering pupal cases attached to the bases of ponderosa pine seedlings below the ground line.

New Decay Information Obtained for Ponderosa Pine in the Black Hills

An intensive millscale study was undertaken to obtain new information needed to improve the estimates of timber volumes and yields of ponderosa pine in the Black Hills of South Dakota. This cooperative investigation involved local forest industries, the Black Hills National Forest, the Forest Products Laboratory, and the Rocky Mountain Station.

The study was based on 1,725 logs cut from 498 trees. The relationship between defect and age is shown by the accompanying illustration.

Red rot, caused by *Polyporus anceps*, was present in 68 percent of the trees, whereas brown cubical rots were present in only 36 percent. Twenty-seven percent of the trees contained both red rot and brown rot. Red rot accounted for 45 percent of the total defect, brown rot 38 percent, and other mechanical defects 17 percent.



The relationship between percent defect and age for merchantable ponderosa pine in the Black Hills.

New Species of Dwarf Mistletoes Discovered in Central America

In cooperation with local foresters and botanists, a study trip was made to the Dominican Republic, Honduras, Guatemala, and Mexico to investigate the classification, hosts, and distribution of the dwarf mistletoes (*Arceuthobium* spp.). Our previous studies had shown that there are 14 dwarf mistletoes in Mexico, but these plants had not been investigated further south. Two undescribed species, one in Guatemala and one in Honduras, were discovered. One of these, *Arceuthobium guatemalense*, is very damaging to a white pine in the highlands of Guatemala. A summary of the dwarf mistletoes affecting pines in Central America (south of Mexico) and the Caribbean area is given below.

Dwarf mistletoe	Host	Distribution
A. bicarinatum	*P. occidentalis*	Dominican Republic, Haiti
A. globosum	*P. rudis, P. caribbea*	Guatemala, British Honduras
A. guatemalense (new species)	*P. ayacahuite*	Guatemala
A. hondurense (new species)	*P. oocarpa*	Honduras

Dead and dying white pines (Pinus ayacahuite) *damaged by a recently discovered species of dwarf mistletoe* (Arceuthobium guatemalense) *in the highlands of Guatemala.*

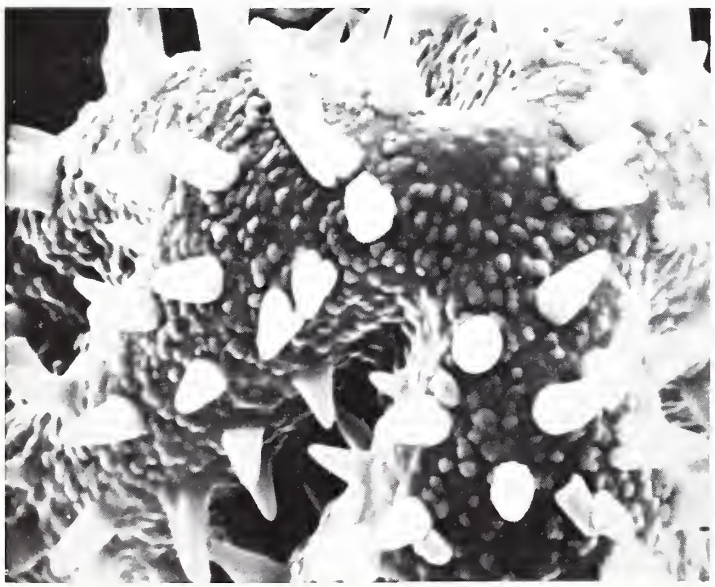
Dothistroma pini Resistance Found in Austrian Pine

Dothistroma needle blight is a devastating disease of young Austrian pine and ponderosa pine plantations in the central and southern Great Plains. Twenty-one geographic sources of Austrian pine were evaluated for resistance to *Dothistroma pini* 5 to 6 years after they were outplanted in eastern Nebraska. Some individual trees within 16 sources were highly resistant; only the Yugoslavian source showed universally high resistance.

Electron Scanning Photomicrographs Aid Taxonomic Studies of Dwarf Mistletoes

Electron scanning microscope studies conducted in cooperation with Dr. Estella B. Leopold of the U.S. Geological Survey yielded new information on the morphology of the pollen grains of *Arceuthobium*, which has aided in the classification of this group. Such studies reveal many features not visible with the most powerful light microscope. Detailed electron scanning studies, in cooperation with Dr. Leopold, are planned for all dwarf mistletoe species. The information gained will not only be of value from a taxonomic standpoint, but it will also, through identification of fossil pollen, aid in interpreting past forest history.

Electron scanning photomicrograph of the pollen grains of Arceuthobium verticilliflorum, *a Mexican dwarf mistletoe (magnification 2,000 times).*



Electron scanning photomicrograph of a pollen grain of Arceuthobium pusillum, *the Eastern dwarf mistletoe (magnification 5,500 times).*

Ponderosa Pine Host for Plant-Parasitic Nematodes

Tests at our Albuquerque, New Mexico, laboratory have shown that ponderosa pine is a host for five plant-parasitic nematodes found in the forest soils of New Mexico: *Hoplolaimus galeatus, Helicotylenchus pumulis, Tylenchorhynchus cylindricus, Xiphinema americanum,* and *X. diversicaudatum.* Ponderosa pine is not a host for *Criconemoides humilis* or *Tylenchus exiguus.*

Ponderosa pine rootlet parasitized by two lance nematodes (Hoplolaimus galeatus). *Note the deformed root tip.*

Aspen Canker Fungi Isolated from Overwintered Insects

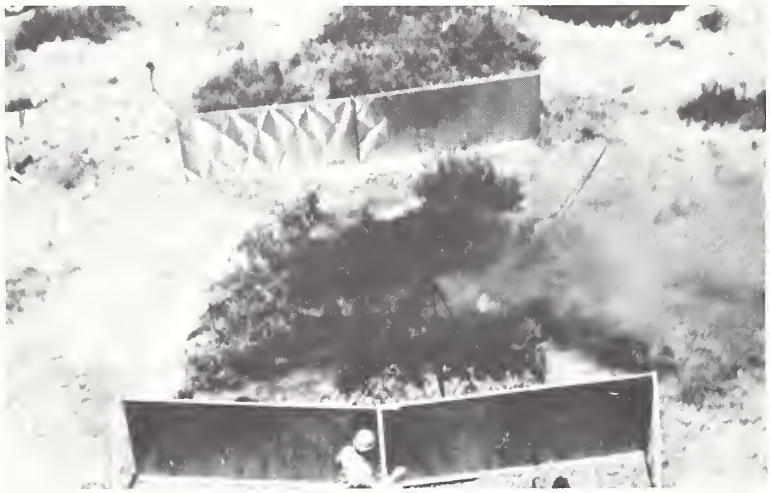
Insects, particularly nitidulids, carry aspen canker fungi, *Ceratocystis* spp., and transmit them to healthy aspen. These insects usually overwinter in the soil. Insects emerging from the soil in the spring were trapped to determine whether they were carrying the fungi. Four species of *Ceratocystis* fungi, including *C. fimbriata,* the most probable cause of *Ceratocystis* canker, were isolated.

Cages placed around the base of aspen trees trap insects emerging from the soil. The insects are examined for canker fungi.

Low Phosphate-Phosphorus Content Increases Rate of Flame Spread in Arizona Chaparral

Carefully instrumented research fires burning Arizona chaparral under outdoor conditions indicated that the phosphate-phosphorus content of the fuel may dramatically affect the rate of flame spread. Four of seventeen fires spread at twice the expected rate, flashing through living leaves and fine twigs while leaving larger stems unburned.

Chemical analysis of the fuels showed that the phosphate-phosphorus content of the fast-burning chaparral averaged nearly 50 percent less (approximately 2,200 versus 4,100 p.p.m.) than that of the slower burning chaparral. Other factors known to affect rate of spread varied little among the various fuels. It is apparent, therefore, that operational models for prescribed fire must incorporate measures of fuel chemistry variation in addition to measures of moisture content, temperature, and other significant factors.



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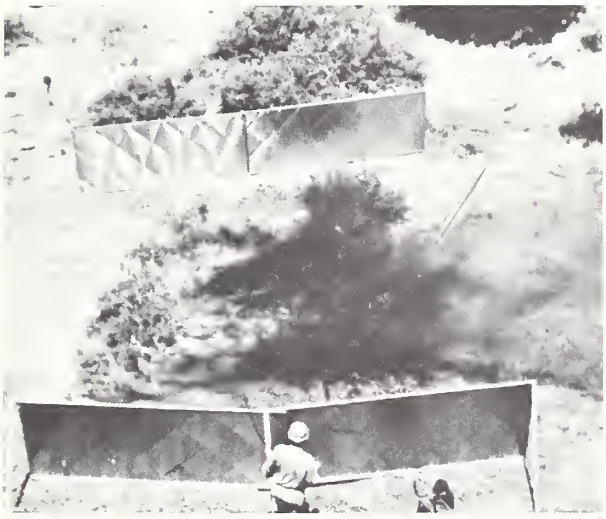

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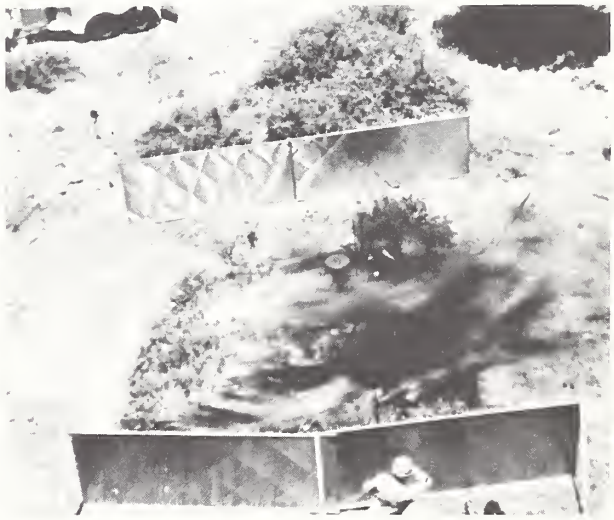


C

A research fire which spread at twice the expected rate in natural Arizona chaparral fuels is shown at ignition (A), midway through the plot 4 seconds after ignition (B), and completely through the plot 8 seconds after ignition (C). Enlargements were made from 16 millimeter documentary color film. Black, blurred portions are dense, ruddy flames.

National Fire-Danger Rating System Undergoing Field Trials

A National Fire-Danger Rating System, developed to make fire control planning and action more effective, was field tested at 46 locations in 1970. The system makes it possible to predict the occurrence, behavior, and suppression difficulty for forest fires under various weather, fuel, and other conditions.

The system will be used on a trial basis by selected national forests and cooperating Federal and State agencies under a wide range of conditions in all regions of the Nation during 1971. Some further modifications may result from these trials, but the system is expected to be fully operational and available for use by fire control agencies in time for the 1972 fire season.

Improved Method Being Developed for Fuel Moisture Measurement

The moisture content of forest litter and other fuel is one of several major indicators of fire danger. Current methods of obtaining fuel moisture information for use in fire-danger rating systems do not provide consistently accurate results.

The theoretical basis for an electronic moisture sensor which would provide a fuel moisture analog has been developed. This device would provide direct, accurate measurement of the moisture content of the various available fuels on the area being rated. Consulting engineers and materials specialists will develop a prototype of the sensor applicable for use with the National Fire-Danger Rating System. The practicability of the device will be evaluated in field trials.

USING AND MARKETING WOOD PRODUCTS

Forest Products Utilization

Composted Sawmill Residues Can Improve Soil Structure and Lessen Air Pollution

We are cooperating with the Colorado State Forest Service and the forest industry to determine the feasibility of producing soil additives on a commercial basis by composting sawmill residue that is too small to chip for pulp.

Disposal costs for such residues continue to increase as additional restrictions are placed on dumping and burning. Use of the material as a soil additive could result in a twofold benefit. First, the structure of many soils would be improved by the addition of humus. Second, the need for disposal methods which cause pollution would be eliminated.

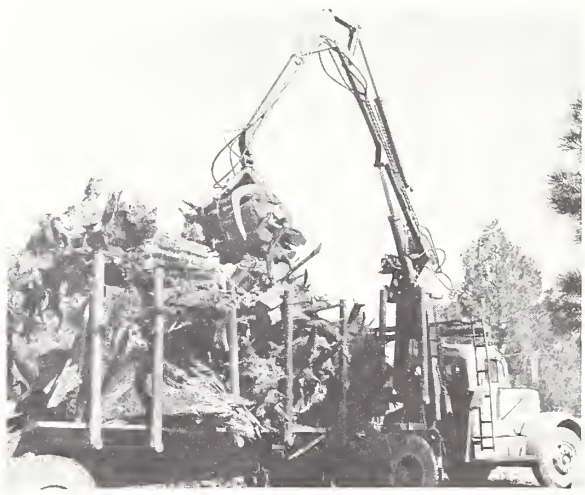
Methods of composting the residues on a commercial scale are being developed. Studies of production costs and market feasibility are also needed.

Naval Stores Produced from Southwestern Ponderosa Pine Stumps

Four hundred tons of ponderosa pine stumps from Arizona produced acceptable yields of rosin, turpentine, and pine oil when they were processed by a Florida wood naval stores firm. This was the first large-scale effort to evaluate southwestern ponderosa pine stumps as a potential resource for the naval stores industry.

Total extractive recovery was higher from ponderosa pine stumps than from southern pine stumps. Extractives from ponderosa pine stumps contain relatively large amounts of longifolene in the pine oil fraction and delta^3-carene in the turpentine fraction. Comparable products from southern pine stumps contain no longifolene and little or no delta^3-carene. Nevertheless, extractives from either source appear equally suitable for many commercial uses. Part of the rosin from the southwestern stumps was used to manufacture commercial paper size which was used by a southern paper manufacturer with satisfactory results.

The southern wood naval stores industry is facing a declining supply of old-growth pine stumpwood. We are cooperating with the Agricultural Research Service, U. S. Department of Agriculture, in the development of reliable estimates of available pine stumpwood in the Four Corners area of Colorado, Utah, New Mexico, and Arizona.



Ponderosa pine stumps from the Southwest were harvested for large-scale commercial processing of naval stores.

Fiber Overlays Improve Lumber Appearance but Require Sound Surface for Successful Application

Excellent surface characteristics can be achieved by applying fiber overlays to low-grade ponderosa pine lumber. The lumber substrate used in our study was selected from a mixed lot of grades 3 and 4 Common ponderosa pine. Without the overlays, these grades are unsuitable for products such as siding where a high-quality finish

is required. Completed research indicates that the upgrading provided by overlays can approximately double the value of such lumber.

Holes, unsound knots, rough grain, and other void-type defects must be repaired if they are to be successfully overlaid with commonly used fiber overlay materials.

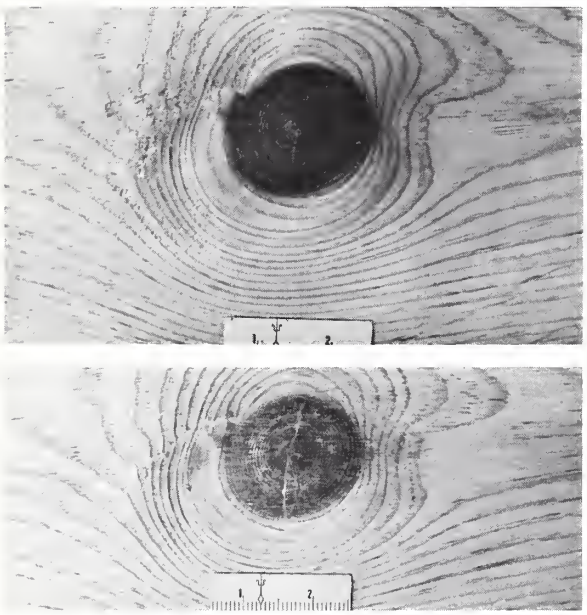
We tested several polyester foams that are technically suitable for repairing most void-type defects. The excellent bond achieved between the wood and the foam is critical because the patch material must shrink and swell with the surrounding wood when the moisture content of the wood changes.

Rough grain, including that caused by planer skip, and torn or pulled grain that commonly occurs around knots, can be corrected by abrasive planing. We found that removal of as little as 20 mils of surface wood from low-grade ponderosa pine lumber corrected this frequent defect, thereby creating a satisfactory gluing surface for the overlay.

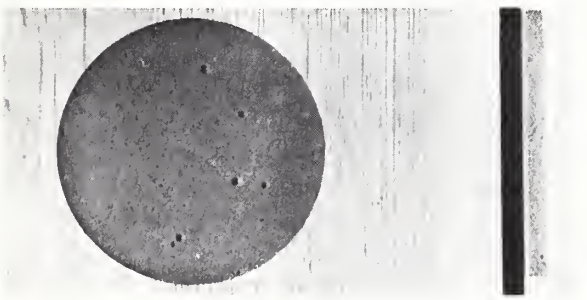
Our tests of a lumber patcher, which replaces defects with a wooden plug, found it to be satisfactory for use with grade 2 Common lumber. Patchers are not a feasible means of repairing grades 3 and 4 Common lumber, however, because defect size in these grades frequently exceeds the 3-inch-diameter plug capacity of available patchers.

Efforts to apply multiple patches to a single large defect were generally unsatisfactory. In most instances, the first patch was dislodged as the second patch was being applied.

Satisfactory patching requires that the grain directions of the board and the patch be matched. If the grain directions are not essentially parallel, joints may open due to differential shrinkage.



The surface of this sample board was too rough for successful application of an overlay (A). Removal of 20 mils of board surface by a single pass through an abrasive planer smoothed torn grain areas sufficiently for overlaying (B).



A polyester foam repair showing the excellent bond between foam and wood after a series of cyclic vacuum/soak-and-dry tests.

Excellent surface characteristics were achieved by applying fiber-overlaid 3 and 4 Common ponderosa pine board-on-board siding to this storage building.

This lumber patcher bores out the defect, applies the adhesive, then cuts and installs a 1.5-inch patch. The entire operation takes only 3 seconds. Units capable of installing 3-inch-diameter patches are available.

Plywood Manufacture Appears Feasible in the Black Hills

Results from a study of potential markets, timber suitability, production costs, and other factors indicate that the production of ponderosa pine plywood could be both technically and economically feasible in the Black Hills.

Marketing factors for plywood produced in the Black Hills appear favorable. Due to freight rates, the Black Hills operator would have an assured price advantage of $7 to $11 per thousand square feet over West Coast producers with respect to major Midwest markets. Although ponderosa pine plywood has strength disadvantages, its lighter weight and superior workability are a major advantage for some applications.

At least 75 percent of all Black Hills ponderosa pine trees having a diameter of 9 inches or larger are suitable for plywood production. Veneer yields from these trees would be more than adequate in grade and amount for the production of construction plywood.

Production costs and estimated returns on investment would vary with plant size. Our study results indicate that a Black Hills plant of relatively small capacity could operate economically, but the expected profit margin would be more attractive for a larger unit.

Ponderosa pine plywood of the type that could be produced in the Black Hills is being used here for sheathing on a high-quality house in Colorado.

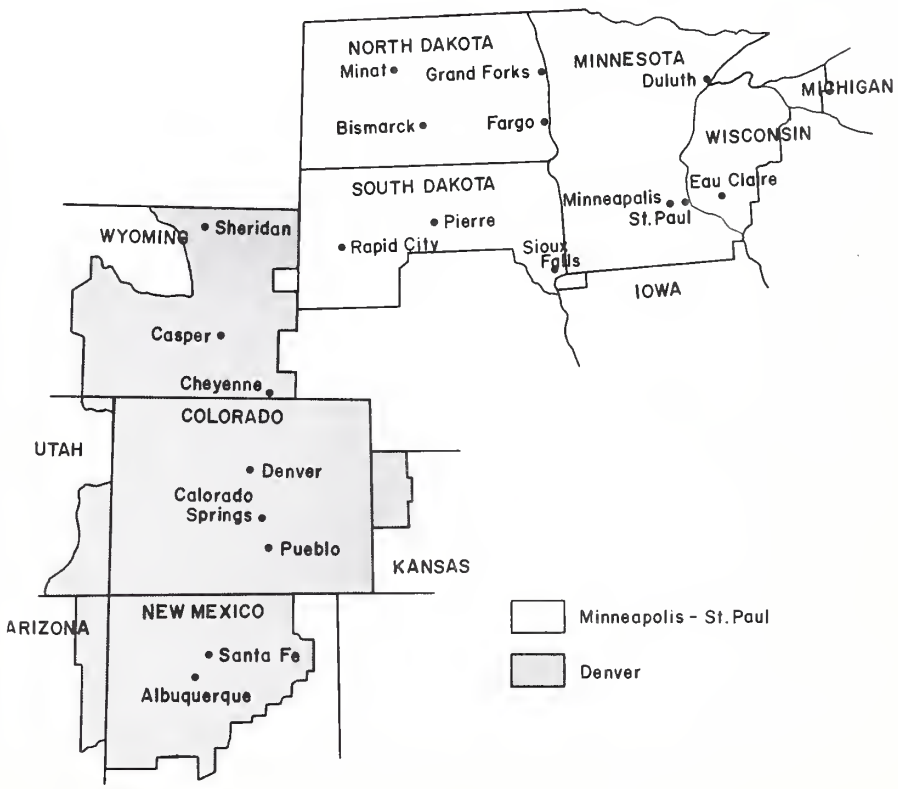
Denver and Minneapolis-St. Paul Trade Areas Offer Market Potential for Rocky Mountain Plywood

Studies of the Denver and Minneapolis-St. Paul trade areas indicate that they could become prime markets for new plywood production in the Rocky Mountain States. These areas annually consume about 600 million square feet of softwood plywood, and their plywood markets are growing faster than the national average. In 1969, the Nation's total plywood sales declined about 4 percent, but plywood shipments to the Denver and Twin Cities trade areas increased 7 and 4 percent, respectively. By 1980, the combined annual requirement for the two areas is expected to reach approximately 1 billion square feet.

At present, more than 80 percent of all softwood plywood shipped to these areas is used for construction. The major applications are roof sheathing, subflooring, and floor underlayment, all of which require a type of plywood usually referred to as "sheathing." Rocky Mountain-produced plywood is especially suitable for sheathing, and it may find additional acceptance for certain special applications such as cabinets and do-it-yourself projects.

Our studies indicate that plywood has a strong position in the Denver and Twin Cities trade areas. Plywood holds a 90-percent share of the roof sheathing market, and it accounts for about 70 percent of subflooring and 65 percent of the underlayment used in single family dwellings and low-rise apartments.

The Denver and Twin Cities trade areas could conceivably absorb all of the potential new plywood production from the Rocky Mountain States, and freight advantages would make these areas favorable outlets. It is likely, however, that a part of any new production would go to more distant markets, as at present. Inland mills (western mills east of the Cascades) ship only about 10 percent of their sheathing production into the Denver and Minneapolis-St. Paul trade areas. Much of the remainder goes to the large markets east of the Mississippi River and north of the Ohio River. It can be expected that the distribution of new Rocky Mountain plywood production would follow a similar pattern.



The Denver and Minneapolis-St. Paul trade areas.

COMMON AND SCIENTIFIC NAMES OF ANIMALS AND PLANTS MENTIONED

ANIMALS

Birds

Grouse, sharp-tailed	*Pedioecetes phasianellus jamesi* Lincoln
Sparrow, Brewer's	*Spizella breweri* (Cassin)
Sparrow, vesper	*Pooecetes gramineus* (Baird)
Thrasher, sage	*Oreoscoptes montanus* (Townsend)
Towhee, green-tailed	*Chlorura chlorura* (Audubon)

Mammals

Cottontail, desert	*Sylvilagus audubonii* Baird
Deer, mule (desert)	*Odocoileus hemionus crooki* (Mearns)
Deer, mule (Rocky Mountain)	*Odocoileus hemionus hemionus* (Rafinesque)
Deer, white-tailed (Coues)	*Odocoileus virginianus couesi* (Coues & Yarrow)
Deer, white-tailed (South Dakota)	*Odocoileus virginianus dacotensis* Goldman & Kellogg
Elk	*Cervus canadensis canadensis* (Erxleben) Reynolds
Ground squirrel, white-tailed	*Citellus leucurus* Merriam
Jackrabbit, black-tailed	*Lepus californicus* Gray
Mouse, Apache pocket	*Perognathus apache* Merriam
Mouse, deer	*Peromyscus maniculatus* Wagner
Mouse, northern grasshopper	*Onychomys leucogaster* Maximilian
Mouse, piñon	*Peromyscus truei* Shufeldt
Mouse, western harvest	*Reithrodontomys megalotis* Baird
Pocket gopher, northern	*Thomomys talpoides* Richardson
Prairie dog, white-tailed	*Cynomys leucurus* Merriam
Rat, desert wood	*Neotoma lepida* Thomas
Rat, Ord's kangaroo	*Dipodomys ordii* Woodhouse

PLANTS

Forbs

Anemone, tuber	*Anemone tuberosa* Rydb.
Bigroot	*Marah gilensis* Greene
Buckwheat, sulfur	*Eriogonum umbellatum* Torr.
Dandelion, common	*Taraxacum officinale* L.
Fleabane, trailing	*Erigeron flagellaris* A. Gray
Geranium, Richardson	*Geranium richardsonii* Fisch. & Trautv.

Grassnuts, purplehead	*Dichelostemma pulchellum* (Salisb.) Heller
Lupine, silvery	*Lupinus argenteus* Pursh
Pussytoes	*Antennaria* spp.
Sagebrush, Louisiana	*Artemisia ludoviciana* Nutt.
Thistle	*Cirsium* spp.
Yarrow	*Achillea* spp.

Grasses and Grasslike Plants

Bluegrass, big	*Poa ampla* Merr.
Bluegrass, Kentucky	*Poa pratensis* L.
Corn	*Zea mays* L.
Cottontop, Arizona	*Trichachne californica* (Benth.) Chase
Fescue, Arizona	*Festuca arizonica* Vasey
Fescue, Idaho	*Festuca idahoensis* Elmer
Fescue, Thurber	*Festuca thurberi* Vasey
Galleta	*Hilaria jamesii* (Torr.) Benth.
Grama, blue	*Bouteloua gracilis* (H.B.K.) Lag.
Junegrass, prairie	*Koeleria cristata* (L.) Pers.
Lovegrass, Lehmann	*Eragrostis lehmanniana* Nees
Lovegrass, weeping	*Eragrostis curvula* (Schrad.) Nees
Muhly, mountain	*Muhlenbergia montana* (Nutt.) Hitchc.
Oat, common	*Avena sativa* L.
Sedge, Ross	*Carex rossii* Boott

Shrubs and Trees

Acacia, catclaw	*Acacia greggii* A. Gray
Acacia, mescat	*Acacia constricta* Benth.
Ash, green	*Fraxinus pennsylvanica* Marsh.
Aspen, quaking	*Populus tremuloides* Michx.
Barrelcactus	*Ferocactus wislizenii* (Engelm.) Britt & Rose
Bitterbrush	*Purshia tridentata* (Pursh) DC.
Buffaloberry, silver	*Shepherdia argentea* (Pursh) Nutt.
Burroweed	*Haplopappus tenuisectus* (Greene) Blake
Calliandra, false-mesquite	*Calliandra eriophylla* Benth.
Ceanothus, desert	*Ceanothus greggii* A. Gray
Chokecherry	*Prunus virginiana* L.
Cholla	*Opuntia spinosior* (Engelm. & Bigel) Toumey
Cotoneaster	*Cotoneaster* spp.
Douglas-fir, Inland	*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco
Elm, American	*Ulmus americana* L.
Elm, Siberian	*Ulmus pumila* L.
Fir, corkbark	*Abies lasiocarpa* var. *arizonica* (Merriam) Lemm.
Fir, white	*Abies concolor* (Gord. & Glend.) Lindl.
Hackberry	*Celtis occidentalis* L.
Honeylocust	*Gleditsia triacanthos* L.
Juniper, Utah	*Juniperus osteosperma* (Torr.) Little
Lilac, villosa	*Syringa villosa* Vahl
Manzanita	*Arctostaphylos* spp.
Mesquite	*Prosopis juliflora* (Swartz) DC.
Mountainmahogany, true	*Cercocarpus montanus* Raf.
Mulberry, red	*Morus rubra* L.
Oak, bur	*Quercus macrocarpa* Michx.

Oak, shrub live	*Quercus turbinella* Greene
Oregongrape, low	*Berberis repens* Lindl.
Pine, Austrian	*Pinus nigra* Arnold
Pine, lodgepole	*Pinus contorta* Dougl.
Pine, ponderosa	*Pinus ponderosa* Lawson
Pine, Scots	*Pinus sylvestris* L.
Rabbitbrush, Greenes	*Chrysothamnus greenei* (A. Gray) Greene
Redcedar, eastern	*Juniperus virginiana* L.
Rose, Woods	*Rosa woodsii* Lindl.
Sacahuista	*Nolina microcarpa* S. Wats.
Sagebrush, big	*Artemisia tridentata* Nutt.
Sagebrush, fringed	*Artemisia frigida* Willd.
Saltbush, fourwing	*Atriplex canescens* (Pursh) Nutt.
Saltbush, Gardner	*Atriplex nuttallii* S. Wats.
Saltbush, shadscale	*Atriplex confertifolia* (Torr. & Frem.) S. Wats.
Serviceberry, saskatoon	*Amelanchier alnifolia* Nutt.
Silktassel, Wright	*Garrya wrightii* Torr.
Skunkbush	*Rhus trilobata* Nutt.
Snakeweed, broom	*Gutierrezia sarothrae* (Pursh) Britt. & Rusby
Snowberry, common	*Symphoricarpos albus* (L.) Blake
Snowberry, western	*Symphoricarpos occidentalis* Hook.
Spruce, Engelmann	*Picea engelmannii* Parry
Wait-a-bit	*Mimosa biuncifera* Benth.
Whortleberry, grouse	*Vaccinium scoparium* Leiberg
Winterfat, common	*Eurotia lanata* (Pursh) Moq.

About the Forest Service . . . .

The Forest Service, U. S. Department of Agriculture, is dedicated to the sustained production of natural resource products and to the protection and enhancement of environmental quality so as to assure the health and well-being of people—now and in the future. Fulfillment of these expectations and needs is sought through three major activities:

1. New knowledge is developed by forest and range research scientists at 80 locations from Puerto Rico to Alaska and Hawaii.

2. The 187-million acre National Forest System is managed for multiple use purposes under sustained yield.

3. Cooperative programs are conducted with States and private citizens in an effort to achieve better management, protection, and use of 395 million acres of State, local, and private forest lands.

The Forest Service, since its establishment in 1905, has provided increasingly greater service to a growing Nation, and it has become a leading natural resource conservation agency.

OFFICES AND LABORATORIES OF THE ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

(In cooperation with Colorado State University)

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